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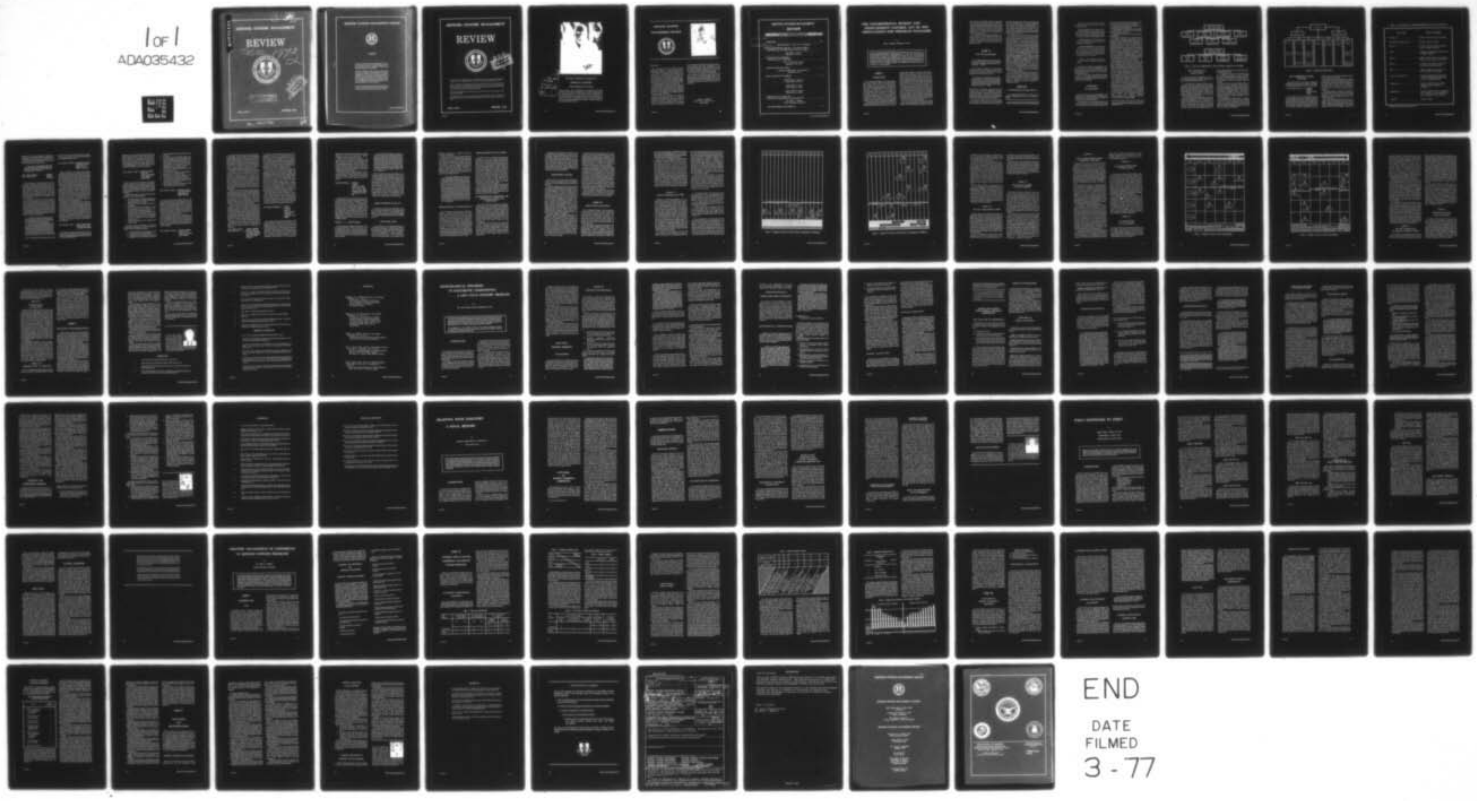

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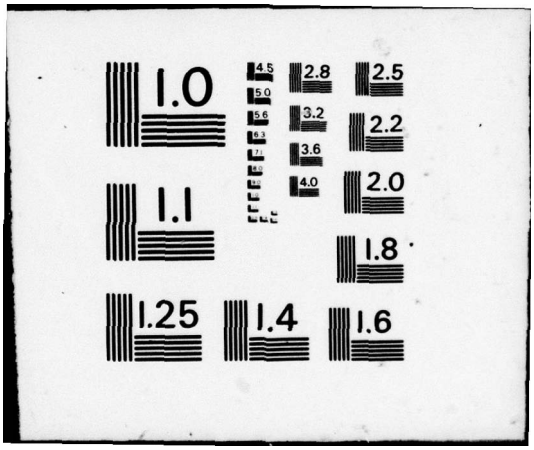
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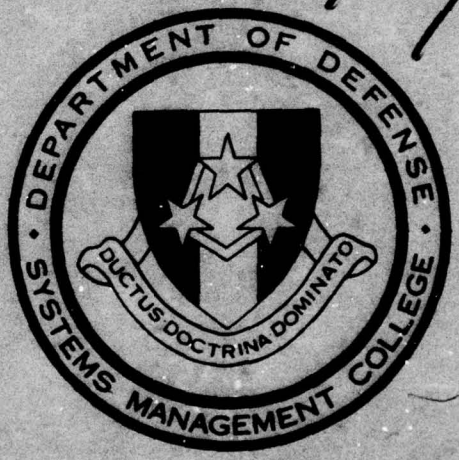

VOL I, NO 1. WINTER 1976

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DEFENSE SYSTEMS MANAGEMENT REVIEW

PURPOSE

The purpose of the Defense Systems Management Review is to disseminate information concerning new developments and effective actions taken relative to the management of defense systems programs and defense systems acquisition.

The Review is designed as a vehicle to transmit, between persons in positions of leadership and responsibility in the program management and systems acquisition communities, information on policies, trends, events and current thinking affecting the practice of program management and defense systems acquisition. The publication serves as a means for providing an historical record of significant information associated with defense systems acquisition/management concepts and practices.

The Review supports the assigned mission of the Defense Systems Management College, and serves as a medium for continuing the education and professional development of persons in the field.

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DEFENSE SYSTEMS MANAGEMENT

REVIEW

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VOL I, NO 1. **WINTER, 1976**

This Page Is Dedicated In Recognition Of

NORMAN R. AUGUSTINE

Under Secretary Of The Army

Who in January, 1976, recognized, and, on behalf of the program management and systems management communities, stated the need for a periodical devoted to the concerns of those responsible for providing the systems and material that arm our nation. His observations on the need for a "truly effective means of communicating with people in the Program Management business" initiated the Defense Systems Management Review.

DEFENSE SYSTEMS

MANAGEMENT REVIEW

Dear Reader:

This is the first issue of the *Defense Systems Management Review,* a quarterly for those who have a responsibility for managing defense systems.

The *Review* is designed to treat specific areas indepth for the serious practitioner of defense systems management. The problems encountered, general and unique, and methods of appropriate problem solution will be reported. Individual applications of proved problem solutions will be presented for consideration and to provoke further study.

The management of defense systems development and production is a maturing field. New ideas and concepts are repeatedly leading to new management approaches. New policies are emerging, replacing older ones. New challenges are developing and answers must be found for them.

In the midst of this movement is a need for improved communications—for an instrument through which managers can transmit the results of experiences. Diverse viewpoints need to be expressed in writing, and appraised. The considerations that shape policies can best be understood when recorded and explained. The interests of program managers and those responsible for the management of defense systems acquisition can well be served through the publication of a periodical that focuses on pertinent and relevant subjects.

As we see it, the mission of the *Review* is to provide a forum for the professional expression of the experiences and progress taking place in the defense systems program management and systems acquisition process. I solicit feedback from you and especially contributions in terms of articles for future issues.

JOHN G. ALBERT
Major General, US Air Force
Commandant

DEFENSE SYSTEMS MANAGEMENT REVIEW

VOL 1, NO 1. WINTER 1976

(cont fr p 1473A)

This issue includes the following articles:

THE CONGRESSIONAL BUDGET AND IMPOUNDMENT CONTROL ACT OF 1974: IMPLICATIONS FOR PROGRAM MANAGERS

by

James A. Francis, Department of Navy

As a result of the Congressional Budget and Impoundment Control Act of 1974, the national budgetary process is now organized in a much more systematic and comprehensive manner than traditionally has been the case. The budgetary process is to be executed on a specified time schedule, with due attention to the state of the total economy and to commitments, both immediate and long term. In this paper the author, a member of PMC-75-2, outlines the new requirements from the point of view of a program manager and evaluates ten areas which may affect his day-to-day operations.

PART I

INTRODUCTION

The Congressional Budget and Impoundment Control Act of 1974 (Public Law 93-344) represents major budget reform on the part of the Congress. The Act will have a significant effect on departments and agencies of the Executive Branch. The purpose of this report is twofold; first, it is to provide an understanding of some of the major procedures and provisions of the Act; and second, it is to identify some of the implications of the Act on Department of Defense (DOD) planning, programming, and budgeting and focus attention on some potential problems that may affect acquisition management.

The approach followed in this study logically fell into three sequential steps. The first was a review of background information pertinent to the Act and its implementation. Based on an analysis of this information, those provisions of the Act that were expected to have the greatest impact on current Defense Department policies and procedures were listed. The second step in the study was to discuss with key Defense and Congressional staff personnel those provisions of the Act which were identified during step one. In these interviews attention was focused on "experience gained" from the recent trial run implementation by Congress of certain provisions of this Act during the Fiscal Year 1976 budget process. The final step in the study was a refinement of this information to identify potential problems that could affect defense planning, programming and budgeting and which will require the continued attention of defense officials in future years when the new provision of the Act become routine.

The next section deals primarily with recent trends in federal spending and the need for budget reform. This is followed by an explanation of many

of the key provisions of the new Act. In discussing these provisions an attempt was made to develop a relationship with the Executive Branch and, in particular, the Department of Defense. When possible, examples were drawn from the recent trial run experience. Ten potential problem areas affecting present policies and procedures of the Department of Defense are discussed.

The assumption is made that the reader is reasonably well acquainted with budget terminology (e.g., budget authority, outlays, deferrals, recision, etc.), Congressional legislative procedures, and the Department of Defense Planning, Programming and Budgetary System.

PART II

THE NEED FOR REFORM

"... The Congress shall have power to levy and collect taxes, duties, imports and excises, to pay the debts and provide for the common defense and general welfare of the United States; ...." (Ref 1).

The Congressional Budget and Impoundment Control Act of 1974 was signed into law by President Richard M. Nixon on 12 July 1974. At the bill signing ceremony the President noted:

"... this bill is the most significant reform of budget procedures since the Congress and this country began. What this bill does is to provide a means whereby the Congress and the Executive, not only now but in administrations to come, will work together to keep the budget from getting out of control...." (Ref 2).

To this end, the Act provides a framework by which Congress can: (1) control obligational authority, outlays, estimated revenues, public debt levels, and the budget surplus or deficit for the budget year; and(2) set priorities for spending among the federal programs, based upon the economy as a whole.

The need for budget reform is clearly evident when looking at the growth of federal spending (outlays) and its impact on the nation's economy. In the past 25 years, since 1951, the spending has increased 304.8 billion* and the gross federal debt has increased 350.7 billion. The budget deficit for FY 76 alone was estimated by the President to be $51.9 billion. Budget authority for interest on the national debt is estimated at $34.4 billion, equal to nearly one third of the budget authority for national defense. (Ref 3, pp 29, 50).

A second key factor of the growing federal budget is the increase in contract, borrowing and entitlement spending authorities, collectively referred to as backdoor spending. This spending, created by prior statutory provisions, is outside the annual appropriation process. In recent years backdoor spending has grown to account for 56 percent of all federal spending (Ref 4, p 2). Of the FY 76 budget submitted by the President, nearly 75 percent of the budget is considered "relatively uncontrollable under existing law," and the uncontrollables represent the fastest growing part of the total budget (Ref 5, p 193). Looking at the President's FY 76 federal spending request for $349.4 billion, only approximately $92.5 billion is considered controllable. Of this, $63.4 billion was requested for defense (Ref 3, p 355). Although defense spending represents only 26.9 percent of total federal spending, it also represents 68.5 percent of the spending which is controllable by Congress. It is not surprising then that the defense budget becomes a primary instrument for adjusting federal spending priorities.

The Congressional Budget and Impoundment Control Act of 1974 is the culmination of nearly 30 years of on-again, off-again attempts by Congress to improve a dated budget process. The Act is intended to provide Congress with control over the federal budget so Congress may better discharge its constitutional duties.

PART III

AN EXPLANATION OF THE NEW ACT

In an explanation prepared for members of the House of Representatives, the Act is outlined as follows:

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*FY 1951 figures were obtained from the United States Budget for Fiscal Year 1953. FY 1976 figures were taken from the President's budget (Ref 3).

The Act contains ten titles which, for purposes of explanation, can be grouped into four major categories, as follows:

TITLES I AND II, which establish new Committees on the Budget in both the House and the Senate and a Congressional Budget Office intended to improve the Congress' informational and analytical resources with respect to the budgetary process;

TITLES III AND IV, which establish a timetable and new procedures for various phases of the Congressional budget process;

TITLES V THROUGH IX, which provide for a new fiscal year, improvements in budget terminology and information to be included in the President's budget submissions, improved program review and evaluation procedures, and effective dates for various provision of the Act; and

TITLE X, which establishes procedures for Congressional review of Presidential impoundment actions.

The discussion that follows will parallel the overall format used in the above explanation to the House members, and will borrow some of the general descriptive narrative given to some of the key provisions of the Act.

The Act creates three new congressional organizations, a new budget timetable, and contains several other provisions designed to strengthen Congress' control of the budget.

COMMITTEES ON THE BUDGET

Title II of the Act creates two Committees on the Budget, one in the House and one in the Senate. The organizations are shown in Figure 1. The duties of the Committees are described below.

1. Report to their respective organizations "concurrent resolutions on the budget" which provide the overall framework of the Congressional Budget, and report reconciliation bills that adjust appropriations to stay within the Congressional Budget.

2. Study and report the effects on budget outlays of existing and proposed legislation.

3. Request and evaluate studies of tax expenditures and methods of coordinating tax expenditures with direct budget outlays; and

4. Review the operations of the Congressional Budget Office.

The Budget Committees were created to perform the new tasks of setting national fiscal policy and setting priorities for federal spending programs. In performing their duties they will recommend to the Senate and House respectively, proper levels of obligational authority, outlays, revenues, and surplus or debt based on existing or projected economic conditions. The recommendations of the Budget Committees when adopted by the Congress in the form of a concurrent resolution on the budget, will provide a framework of budget targets, at a macro level, that will focus the efforts of the other Congressional committees to achieve a unified federal budget which is responsive to the nation's needs.

The House Committee has 25 members. The Senate Committee has 16 members. Both committees are organized into Task Forces as shown in Figure 1. Organizing by Task Force instead of by the traditional subcommittee method has several advantages which, according to one informed source,* reduces formality and improves committee flexibility. For example: subcommittees have their own staffs whereas the Task Forces will draw from the staff of the full committee; the subcommittee chairmen are approved by the party caucus, however, this is not required for a Task Force chairman; to dissolve a subcommittee requires the approval of Congress, whereas a Task Force can be dissolved by committee vote; and subcommittees operate to established rules which need not be followed by a Task Force. From this, one can infer that Task Forces will be created and dissolved based on the changing economic conditions of the country. A key point to note from Figure 1 is that both committees have a Task Force for Defense (National Security/Defense). This is an indication of the interest that each has in the defense budget.

*Interviews were conducted with nonattribution and therefore are not referenced in this report. The thoughts expressed are the author's interpretation of what was said.

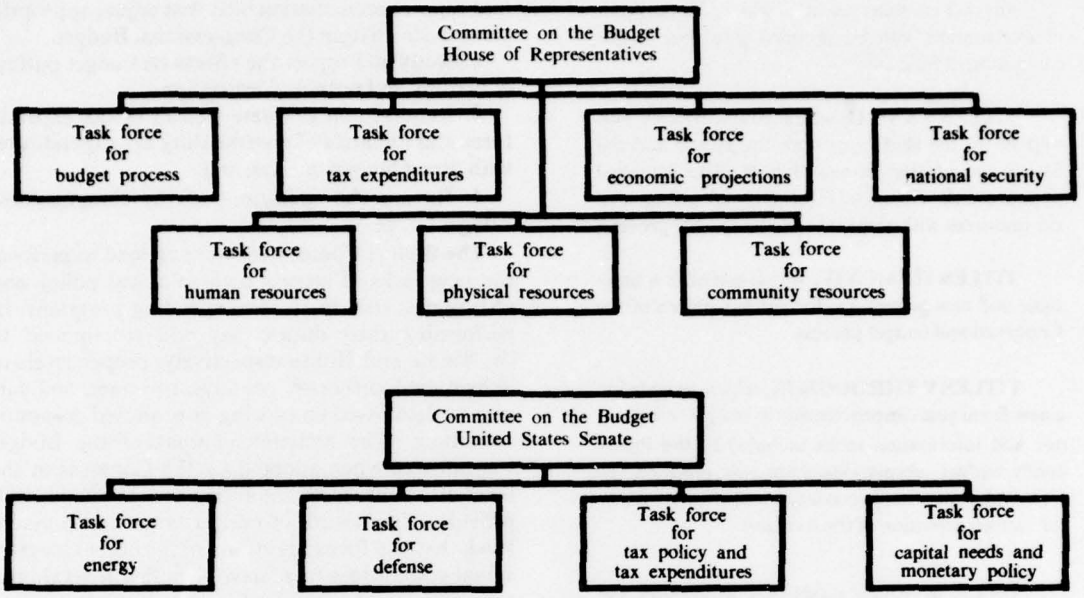

Figure 1. Task Force Organizations for House and Senate Committees on the Budget

THE CONGRESSIONAL BUDGET OFFICE

The third organization established by the Act is the Congressional Budget Office. The principal duties and responsibilities of this office are:

1. To provide direct nonpartisan support to both the House and Senate Committees on the Budget regarding taxing and spending legislation, and upon request, provide assistance to the Committees on Appropriations, Ways and Means, Finance, and other Committees and Members of Congress, and information that will assist them in the discharge of matters within their jurisdiction;

2. To assume the duties and functions of the Joint Committee on Reduction of Federal Expenditures, which was abolished by the Act. Perhaps the most important function inherited from the Joint Committee is scorekeeping, the tracking of spending decisions of the numerous Congressional committees and relating them to the budget authority and outlay targets established in the concurrent resolutions of the budget; and

3. To submit on or before 1 April of each year to the two Budget Committees a report on budget policy and national priorities for the next fiscal year. The report will present alternative budget levels at the aggregate as well as by major functional category.

In the conduct of its duties, the Budget Office is authorized to secure information, data, estimates and statistics directly from the various departments, agencies and establishments of the Executive Branch. In addition, the Budget Office is authorized to obtain similar information, and use the facilities, services and personnel, from the General Accounting Office, Library of Congress, and Office of Technology Assessment.

The Congressional Budget Office is presently organized into the seven divisions shown in Figure 2, and has a staff of about 200. The National Security and International Affairs Division, which deals with DOD, is scheduled to have a total of 30 persons, including 24 professionals.

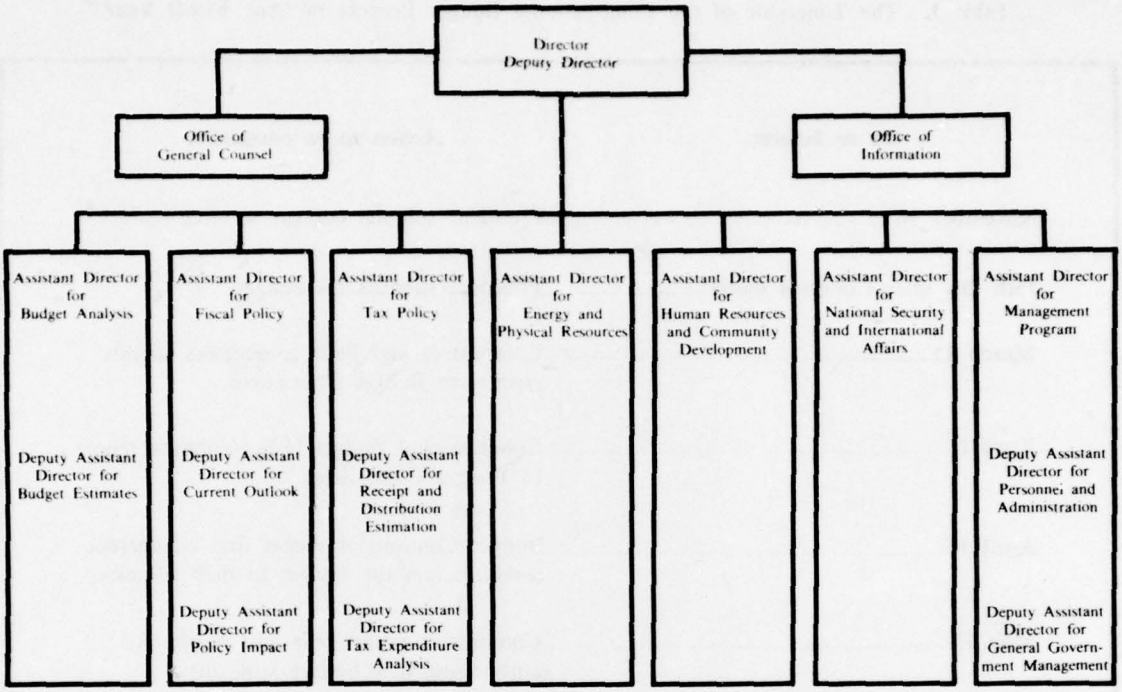

Figure 2. Congressional Budget Office

THE CONGRESSIONAL BUDGET TIMETABLE

Section 300 of the Act sets forth the Congressional budget timetable shown in Table 1. The following paragraphs describe the events of the timetable.

On or before 10 Nov.....President submits current services budget.

Section 605(a) of the Act requires the current services budget to provide the estimated outlays and proposed budget authority to continue existing programs and activities at the same level of effort under the same policies as the fiscal year in progress. The economic and programmatic assumptions (e.g., inflation, economic growth, unemployment, pay increases, etc,) used to develop the budget estimates are to accompany the estimates.

The purpose of the services budget is to provide Congress with detailed information with which to begin analysis of the budget for the upcoming fiscal year. Note that the current fiscal year will be in progress for only a little more than 1 month before the submission of the current services budget is required.

The Joint Economic Committee is required by Section 605(b) of the Act to submit an economic evaluation, based on the current services budget estimates, to the two Budget Committees on or before 31 December.

Talks with an informed source indicate that the Budget Committees will view the current services budget as the cost of continuing government operations. The differences between the current services budget and the President's budget in January will

Table 1. The Timetable of the Congressional Budget Process for Any Fiscal Year [a/]

On or before:	*Action to be completed*
November 10	President submits current services budget.
15th day after Congress meets	President submits his budget.
March 15	Committees and joint committees submit reports to Budget Committee.
April 1	Congressional Budget Office submits report to Budget Committees.
April 15	Budget Committees report first concurrent resolution on the budget to their Houses.
May 15	Committees report bills and resolutions authorizing new budget authority.
May 15	Congress completes action on first concurrent resolution on the budget.
7th day after Labor Day	Congress completes action on bills and resolutions providing new budget authority and new spending authority.
September 15	Congress completes action on second required concurrent resolution on the budget.
September 25	Congress completes action on reconciliation bill or resolution, or both, implementing second required concurrent resolution.
October 1	Fiscal year begins.

[a/] Source: Public Law 93–344, Section 300

represent the cost of new initiatives. Although admittedly an oversimplification, the Committees will be looking closely at the increases and decreases in spending proposed by the President to the current services budget. Stated another way,

> **"... The current services budget provides the baseline or benchmark against which alternative budget totals, including those proposed by the President, can be measured and compared...." (Ref 6, p 8).**

On or before 15th day after Congress meets . . . . . .President submits his budget.

This milestone in the budget process remains essentially unchanged from previous years. The President's budget is his statement of national economic objectives and reflects his policies and spending priorities to achieve these objectives. The Congress views this budget as one of several budget alternatives to be considered during the ensuing months of hearings and debate prior to adopting a first concurrent resolution on the budget (to be discussed later).

One important departure from the traditional process is the requirement of Section 603 of the Act that the budget provide projections for the 4 fiscal years immediately following the budget year. Previously budget decisions were often made without regard to future spending, which sometimes led to conflicting priorities in future budgets. Mr. Schultze of the Brookings Institution in testimony before the House Committee on Rules emphasized the need to look at future costs of programs:

> **"... Let me give you one more example which is my favorite one. Between 1967 and 1971 – I think my numbers are approximately correct – the budget of HEW went up by $26 billion which is about 90 some percent.**
>
> **Ninety-five percent of that huge increase went for four programs, public assistance, medicaid, medicare, and social security. If you had set 100 people down in a room in 1967, representing different points of view and said, "I am going to give you $26 billion to spend for the benefit of the American people, where would you put it," I bet you not one of them would have come out suggesting that particular concentration in just four areas...." (Ref 7, p 323).**

Thus, in recognizing the shortsightedness of the past, the Act contains several provisions that enable Congress to determine if the programs are affordable over extended periods of time.

On or before 15 March ....Committees and Joint Committees submit reports to the Budget Committees.

Section 301(c) of the Act requires each standing committee of the House and each standing committee of the Senate to submit to their respective Budget Committees their views and estimates on all budget matters, including new budget authority and outlays relating to subjects under their jurisdiction. The Joint Economic Committee and the Joint Committee on Internal Revenue and Taxation will likewise submit a report to the two Budget Committees.

The purpose of these reports is to obtain recommendations from the joint and standing committees regarding the budget 1 month in advance of the reporting date of the first concurrent resolution on the budget. One informed source pointed out that from the standpoint of the Executive Branch, this is potentially a key point in the budget process. It provides the first look at what the Congress is thinking for the upcoming fiscal year.

Furthermore, it was pointed out that when this budget process is fully implemented, the Authorization Committees could begin hearings shortly after completion of the current year budget. This would be in early fall, based on the authorization requests submitted the previous May (as amended*). Thus, reports submitted by the Authorization Committees are likely to include estimates based on their fall hearings, and an analysis of the current services and President's budgets. Conversely, the Appropriation Committees' estimates are likely to be based on historical data.

On or before 1 April.....Congressional Budget Office submits report to Budget Committees

This report is expected to play a key role in the

*Amended authorization requests for the budget year will be necessary to account for the final budget adjustments during the second concurrent resolutions and reconciliation process.

budget process. As provided by Section 202(f), it will include: alternative levels of total revenue, total new budget authority, total outlays, and related surpluses and deficits; the estimated levels of tax expenditures under existing laws; and a discussion of national budget priorities, including alternate ways of allocating budget authority and budget outlays, by functional category, to meet national needs.

On or before 15 April.....Budget Committees report first concurrent resolution on the budget to their Houses.

Based upon the Joint Economic Committee's economic evaluation of the current services budget, the recommendations of the standing and joint committees, the Congressional Budget Office's report, and the Budget Committee hearings, the Budget Committees report the first concurrent resolution on the budget.

Section 301(a) of the Act requires the concurrent resolution to set forth the following:

- The appropriate level of budget outlays and new budget authority, both in the aggregate, and by each functional category;
- The amount, if any, of surplus or deficit in the budget;
- The recommended level of federal revenues and the amount, if any, by which the revenues should be increased or decreased;
- The appropriate level of public debt and the amount, if any, by which the statutory limit should be increased or decreased, and resolutions to be reported by the appropriate committees;and
- Other matters relating to the Congressional budget process.

The report which accompanies the concurrent resolution on the budget on 15 April is required by Section 301 (d) to include the following:

- A comparison of the revenue estimates of the committees and that of the President;
- A comparison of the committee estimates of appropriate levels of total budget outlays and total new budget authority with those of the President;
- An allocation of total budget outlays and total new budget authority by function, each function divided between proposed and existing programs, with the latter further subdivided between, first, permanent and regular appropriations, and second, between controllable and uncontrollable amounts;
- An allocation of the level of federal revenues among major sources;
- The economic assumptions and objectives upon which the resolution is based;
- Projections for a period of 5 fiscal years by function beginning with the budget year;
- A statement of any significant changes in the proposed level of federal assistance to state and local governments; and
- Information, data and comparisons on which the committee based the resolution.

On or before 15 May.....Committees report bills and resolutions authorizing new budget authority.

The Act requires (Section 402(a)) that any legislation authorizing new budget authority for the budget year be reported in each House on or before 15 May. This is a deadline; after that date, consideration of authorization measures in the House is permitted only if an emergency waiver reported by the Rules Committee is adopted (exempted from this reporting requirement are entitlement bills and omnibus social security legislation).

The reporting of authorization legislation by 15 May is considered critical to the new budget timetable. Note authorization requests are now submitted 1 full year in advance of this reporting date. (Section 607). This should encourage hearings to begin in early fall, but probably not before the new fiscal year begins.

On or before 15 May.....Congress completes action on first concurrent resolution on the budget.

In a loose analogy, the first concurrent resolution on the budget can be likened to the Planning and Programming Guidance Memorandum (PPGM) used by the Department of Defense, in that it establishes the fiscal constraints, or fences, for the rest of the Congressional Budget process (although Section 304 of the Act permits revision of the resolution). That is, it is the Congress' statement of what the nation can afford in the approaching fiscal year.

The adoption of the first concurrent resolution is a focal point in the new budget process. The Act does not permit (Section 303) either the House or the Senate to consider any bill or resolution that provides new budget authority, an increase or decrease in revenue, an increase or decrease in public debt, or payment under contract or borrowing authority which has not been provided for in advance by an appropriation act, until the first concurrent resolution on the budget has been agreed to. Thus, meeting this deadline is crucial to the process that follows.

The first concurrent resolution on the budget, as noted earlier, is reported out of the Budget Committees of each House on or before 15 April. This allows 30 days for the House and Senate to act, the conferees to agree on a final resolution and submit their conference report, and the Congress to adopt the final resolution. Floor consideration in the House requires a 10-day layover so that members can study the resolution and the accompanying report.

The Act also provides in Section 302 that a joint explanatory statement of managers accompany the conference report. The statement will include an estimated allocation of the total new budget authority and total budget outlays among the committees of the House and Senate having jurisdiction for providing such authority. Each committee to which an allocation is made will then further subdivide its allocation among its subcommittees. These allocations are to be still further subdivided between controllables and other amounts. The provision is also made that each committee will then promptly report to its House, the above subdivision of allocations.

On or before 7th day after Labor Day ..... Congress completes action on bills and resolutions providing new budget authority and new spending authority.

The 7th day after Labor Day can be as early as 8 September or as late as 14 September. Still to be completed is action on the second required concurrent resolution on the budget, and, if necessary, action on the reconciliation bills or resolutions (each to be discussed below). This will make September a very busy month for Congress, and emphasizes the importance of meeting or improving on this milestone if the fiscal year is to begin 1 October.

During the 3 1/2 to 4 months from adoption of the first concurrent resolution on the budget and completion of action on new budget authority and spending authority bills, the various committees will hold hearings and the Congressional Budget Office will perform its key role of scorekeeping, (comparing Congressional actions with the first budget resolution). In addition, Section 403 of the Act directs the Congressional Budget Office to prepare cost analyses and 5-year projections of all public bills (except appropriation bills). These cost estimates are to be compared with any available from the committee, or other federal agency, and are to be included in the report that accompanies the bill.

Note that during the months leading to the reporting of bills that provide new budget authority and new outlay authority, Congress will be working to control long term costs. Thus, in justifying and tracking its requests, the Executive Branch will have to pay close attention to the out-year costs and economic assumptions being used in the analyses.

On or before 15 September ..... Congress completes action on second required concurrent resolution on the budget.

The second required concurrent resolution on the budget reaffirms or revises the first, based on the spending actions of Congress and any unforseen changes in the nations's economy. Furthermore, the second resolution can set in motion the reconciliation process. Reconciliation takes place only if it is necessary to revise existing law, or pending legislation, to achieve the levels set forth in the second resolution. Thus, the second resolution may direct committees with jurisdiction over such changes to

determine and recommend rescinding or amending legislation, raising or lowering revenue, adjusting the debt, or any combination of the above.

Unlike the first concurrent resolution on the budget, the second resolution, when adopted, establishes ceilings, not targets, for all subsequent revenue and spending legislation. However, Section 311 of the Act further provides that the ceilings established by the second resolution apply to total budget authority and total outlay authority, and not to the estimates by functional category.

The Act provides no specific deadline for reporting the second concurrent resolution (as it did for the first resolution—1 April), however, the Budget Committees will probably begin preparations in August.

On or before 25 Sept.....Congress completes action on reconciliation bill or resolution, or both, implementing second required concurrent resolution.

Section 310(c) of the Act provides that reconciliation of legislation solely within the jurisdiction of one committee will be reported to the House or Senate by that committee. However, if reconciliation is directed at more than one committee of the House or the Senate, each committee will promptly make recommendations to the Budget Committee which will compile the recommendations, without substantive change, into a single reconciliation bill or resolution. Finally, Section 310 (f) of the Act directs that Congress may not adjourn *sine die* until it has completed action on the second resolution and reconciliation process.

1 October ..... Fiscal Year begins.

The Congressional budget timetable ends with the beginning of the new fiscal year. However, it is only a little more than 1 month before the President will submit his current services budget and the clock starts ticking for the next budget. The importance of timing in the new budget process has been stated as follows:

> **"... Certain parts of the budget process cannot move ahead unless other actions are completed. Appropriations cannot be considered until the first budget resolution is adopted and necessary authorizations have been enacted. Reconciliation actions cannot be undertaken until action is completed on appropriation bills and the second budget resolution. Thus failure to complete a particular action on schedule affects later actions as well. In short, the four main phases of the budget process (authorization, budget resolution, spending measures, and reconciliations) must be completed by the dates assigned to them in the Act...." (Ref 4, p 15).**

Before leaving the Congressional Budget Timetable and discussing other provisions of the Act, it should be emphasized that September promises to be a very demanding month, both for the Congress, and for the Executive Branch. With the completion of spending bills, the adoption of the second concurrent resolution, and the reconciliation process, last minute changes are almost a certainty. From the point of view of the Executive Branch, the current services budget is but a little more than a month from submission and the time the hearings on authorizations will be starting. Thus the effects of these changes must be analyzed and reflected in the current services budget and committee hearings.

OTHER PROVISIONS OF THE ACT

In addition to the three new organizations, and the new budget timetable, the Act contains several other provisions worthy of note that depart from tradition. In general, these provisions are designed to strengthen Congressional control of the budget process.

A NEW FISCAL YEAR

As was implied by the preceding discussion on the timetable, beginning in calendar year 1976 the fiscal year began 1 October and ended 30 September. The shift from the traditional 1 July—30 June fiscal year was accomplished by a transition budget to cover the three months from 1 July—30 September 1976. The transition budget was submitted by the

President to Congress on 3 February 1975 along with the FY 1976 budget.

This change allows Congress 3 months additional to complete its work on the budget before beginning a new fiscal year. This, coupled with the possibility that authorizing legislation will begin earlier and that the current services budget will be submitted by 10 November, is expected to significantly reduce the need for continuing appropriations resolutions. In testimony before the Joint Study Committee on Budget Control, Congressman Marvin L. Esch (R-Michigan) discussed the continuing resolution and a need for reform. He pointed out:

> **"...The continuing appropriation process does little to assure careful federal planning. It helps to create an uneven funding pattern for federal programs. Many may be funded late in the fiscal year so that federal officials are forced to "use or lose" funds in a short period of time because funds not used by the end of the fiscal year revert back to the Treasury. Since 1964 the average delay between the beginning of the fiscal year and the passage of all appropriations acts has been over 3 months. In the last 9 years we have passed a total of only seven appropriation acts before the beginning of the fiscal year. This record rests on the base of 116 appropriation measures presented during that period. During our consideration of the fiscal year 1972 budget, four of the 14 measures considered were passed later than 4 months into the new fiscal year. One of the bills was finally passed 252 days into the new fiscal year...." (Ref 8, p 361).**

MIDYEAR REVIEW AND SUPPLEMENTALS

Title VI of the Act requires that the President's budget be updated twice annually, on 10 April and 15 July, the latter being the midyear review which previously occured on 1 June. The budget updates are to state all amendments or revisions to the budget authority requested, the estimated outlays, and the estimated receipts for the ensuing fiscal year as set forth in the President's budget submitted in January. The purpose of the supplemental budget requests is to provide a means for adjusting to changing economic conditions as the budget process moves forward. In the past 5 years Congress passed 29 supplemental appropriations bills, and in the last 9 years, nearly $10 billion per year has been appropriated through supplementals. (Ref 8, p 366).

PROGRAM REVIEW AND EVALUATION

Title VII of the Act authorizes House and Senate committees to carry out analysis, appraisal and evaluation of Government programs and activities. These may be conducted by the committees, under contract, or by a Government agency by direction of the committees. Furthermore, it creates within the General Accounting Office an Office of Program Review and Evaluation not to exceed ten experts (on a permanent, temporary or intermittent basis) to assist the committee of each House in developing a set of legislative objectives and goals, and the methods for assessing and reporting actual program performance in relation to these objectives and goals. In addition, this new office will assist the committees in analyzing the reports and studies prepared by and for any federal agency.

This provision of the Act indicates Congress will be reviewing Government programs and analyzing costs in comparison with benefits, to determine if legislative goals and objects are being met. It is not known at the time of this writing to what depth and detail these studies will be conducted.

STANDARDIZED DATA PROCESSING AND INFORMATION SYSTEMS, AND TERMINOLOGY

Title VIII of this Act amends the Legislative Reorganization Act of 1970 to direct the Secretary of the Treasury and the Director of the Office of Management and Budget, in cooperation with the Comptroller General, to develop, establish and maintain standardized data processing and information systems for fiscal, budgetary and program related data and information. These systems are to be used by federal agencies, and should, to the extent practical, meet the needs of state and local governments.

Furthermore, the title directs the Comptroller General, in cooperation with the Secretary of the Treasury, the Office of Management and Budget and the Congressional Budget Office, to develop, establish, maintain and publish standard terminology, definitions, classifications, and codes for federal fiscal, budgetary and program related data and information.

The purpose of these provisions of the Act is to standardize fiscal and budgetary reporting to enable meaningful comparison and analyses of data across government departments and agencies. As one source pointed out, one problem faced by Congress today is the large volume of data it receives, with much of it never being used. As a result, Congress must determine not only how much data it needs, but also what kind of data it needs. Hopefully, the standardization of data processing and terminology will assist in solving these problems.

IMPOUNDMENT CONTROL

Title X of the Act deals with impoundment control. The title recognizes two types of impoundment actions by the Executive Branch: recisions and deferrals.

A recision of budget authority must be proposed whenever the President determines that all or part of the budget authority will not be required to carry out the full objectives or scope of a program due to fiscal policy or other reasons (e.g., termination of authorized programs), or whenever all or part of the budget/authority provided for only 1 fiscal year is to be reserved from obligation for such fiscal year. The Act requires the President to submit to Congress a special message requesting recision of the budget authority, and explaining fully the circumstances and reasons including, to the maximum extent possible, estimated fiscal, economic, and budgetary impact of the proposed recision. Unless both Houses of Congress complete action on a recision bill within 45 days, the budget authority must be made available for obligation.

Likewise, a deferral of budget authority by the President, Office of Management and Budget, or head of any department or agency requires the President to submit to Congress a special message setting forth: the amount of budget authority to be deferred; to the maximum extent possible, the estimated fiscal, economic and budgetary effects; and other circumstances and considerations which have a bearing on the deferral. The President is required to make such budget authority available for obligation if either House passes an impoundment resolution disapproving the deferral at any time after receipt of the special message.

Recision and deferral messages are to be delivered the same day to the House, Senate and Comptroller General. In addition, these messages are to be published in the Federal Register, in the first edition following transmittal to Congress. The Comptroller General serves as the watchdog for Congress in matters pertaining to recisions and deferral with authority to use civil action to insure compliance.

Executive impoundment of Congressionally appropriated funds became an important issue during the Nixon administration. The Congress viewed impoundment as an infringement on its constitutional duties and responsibilities, and a weakening of its power to set national priorities by control of the purse strings. The Congressional Budget and Impoundment Control Act of 1974 brings Congressional budget reform and impoundment control together in a way that is intended to provide a meaningful, systematic and timely approach to establishing priorities and controlling economic growth through the cooperation of both the Congress and the Executive Branch of Government.

The next section of this report deals specifically with the Department of Defense and some of the implications the Act will have on the planning, programming and budgeting of defense programs.

PART IV

IMPLICATIONS FOR DEFENSE

The Congressional Budget and Impoundment Control Act of 1974 provides a major reshaping of the Congressional budget process as well as new procedures and provisions that strengthen Congress' control over the budget. Some of the new procedures and provisions will require changes to the way the Executive Branch conducts business. In addition, the work load to prepare and justify the budget will increase.

Even before the Act was signed, the Office of the Secretary of Defense (OSD) was preparing for implementation. A preview of things to come was prepared (Ref 9) prior to enactment of the new legislation, and was later updated and published in the *Federal Accountant* (Ref 10). Following the bill signing, briefings were conducted to inform key

people within the Department of Defense of the Act and some of its implications (Ref 11). The discussion which follows identifies ten potential problem areas taken from this background material.

Figure 3 shows the DOD Planning Programming and Budgeting System (PPBS) married to the new Congressional budget timetable. Although this appears simple at first glance, it must be remembered that the budget process is a yearly event. To show the complications of these cyclical events, the budget process is reformated in Figure 4 to match the 12 month calendar. Here it is quite evident that each year, DOD management must: (1) execute the current year budget; (2) follow and provide support to Congress during consideration of the next fiscal year budget; (3) complete the programming phase of the budget year +1 budget; and (4) initiate the planning phase of the budget year +2 budget. This is not all new, but it will be necessary to refer to the schedule of events shown in Figures 3 and 4 to assess the full impact of the new Act on acquisition management.

Problem #1

Advanced Authorizations and the PPBS

Requests for authorizing legislation are to be submitted to Congress by 15 May of the year preceding the fiscal year for which this request is made — 16 1/2 months in advance. Figure 4 shows that in terms of the PPBS, DOD will still be in the programming phase with the preparation of the Program Objective Memorandums (POMs). The POMs will not have been reviewed by OSD, and Program Decision Memorandums (PDMs) from the Secretary of Defense defining the approved programs are not normally issued until July or August. Furthermore, as pointed out by one source, the figures contained in the POMs are not budget quality, i.e., they are rough and unworked numbers. Thus, from the standpoint of authorizing legislation, the approved program will reflect the force levels, program decisions and total obligational authority levels approved the preceding year, nearly 27 months before the fiscal year is to begin.

To comply with this provision of the Act, the current policy is for the President to submit, in January, his budget for the approaching fiscal year, and his authorizing requests for the year that follows. Thus, budget quality figures must be prepared for 2 fiscal years for those programs requiring authorizations. The effect is an increased workload during the budgeting phase of PPBS. In addition, as one official pointed out, Congress is operating on a tighter schedule and insisting on no slippage. This means that the budget reviews must be completed, and approved, and the budget printed on schedule. Although it is not planned to begin the budgeting phase any earlier than the present 1 October date, it will be necessary to end earlier. That is, as one official expressed it: "the system will need tightening up—the schedule is tougher."

Looking at the Congressional side, it is not likely that the Authorization Committees will take any significant action on the authorization requests until the following fall when hearings are expected to begin. Thus, in addition to preparing for the President's budgets the DOD almost certainly will want to submit amendments to the authorization Committees at this time. These amendments may be necessary for several reasons:

1. The requests held by the committees at this time will reflect force levels and program decisions established nearly 15 months earlier. Force levels and program decisions approved in the most recent PDM's (3 months earlier) may require adjustment.
2. The budget policies and decisions used to estimate the total obligation authority will be nearly 12 months out of date, and
3. Congress will have just completed action on the current budget; Thus, the effects of the completed Congressional action on this budget will have to be determined and allowances made to report program changes that affect authorizations for the coming year.

From the standpoint of the program manager, the requirement for advanced authorizations will place increased emphasis on high quality cost estimating over a longer time frame. In addition, it is likely to increase the typical workload within the program management office, because authorizations will now be reviewed by OSD twice. The estimates will have to be tracked during the intervening year, and updated with an explanation of the differences at the second budget review. The differences may be

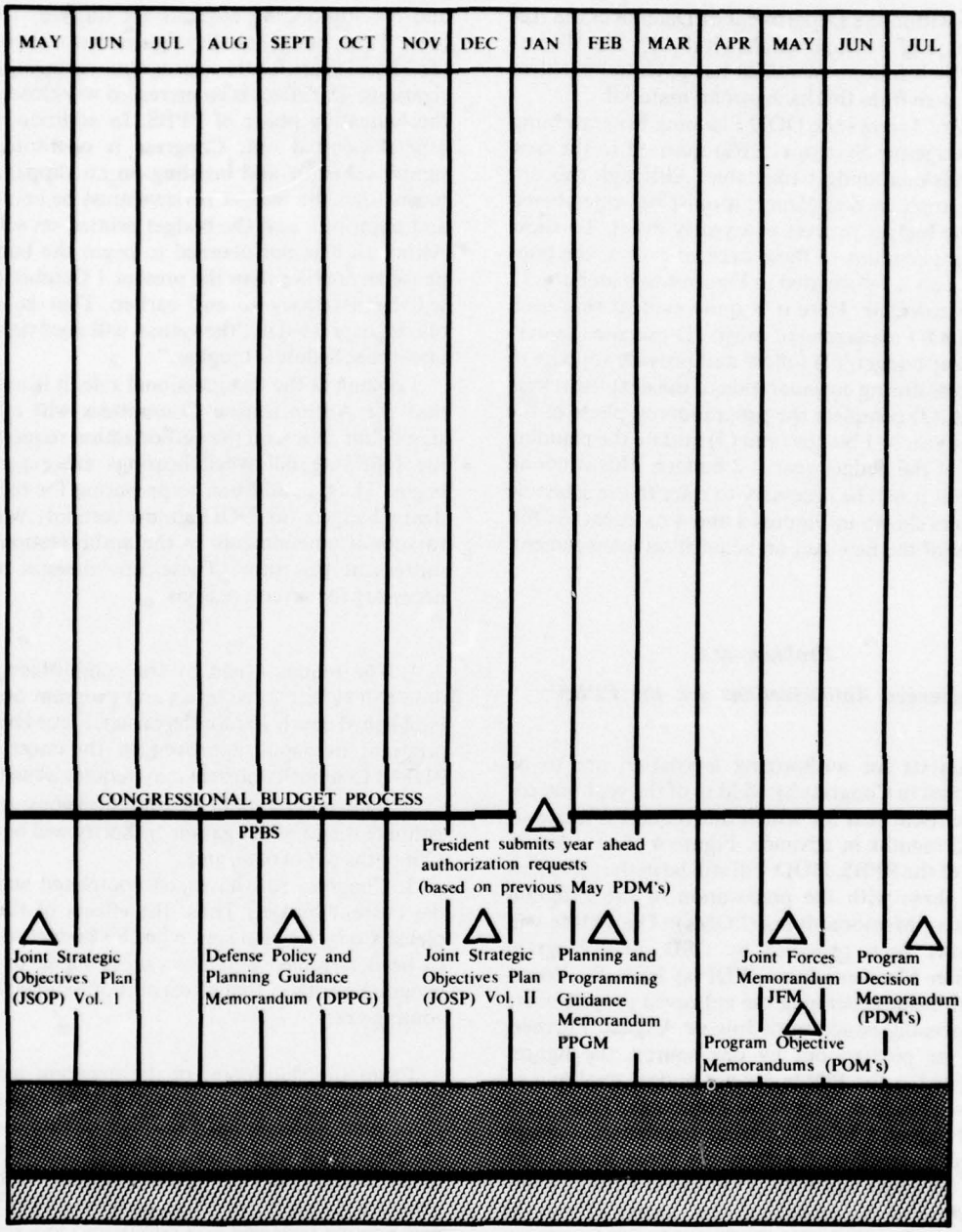

Figure 3. Schedule of Events for DOD Planning, Programming and Budgeting

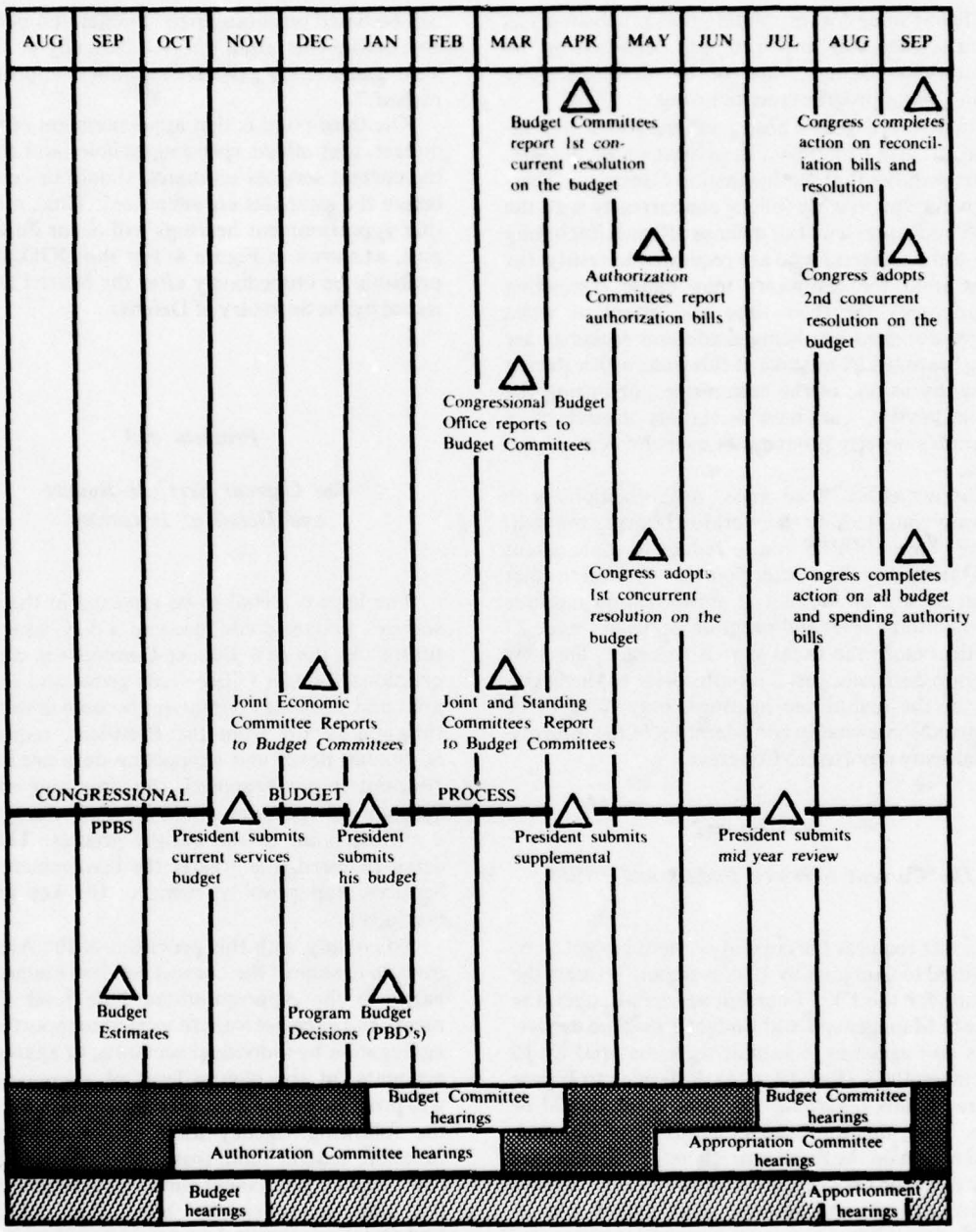

Figure 3. Schedule of Events for DOD Planning, Programming and Budgeting

significant since cost estimating is as much an art as it is a science and since program decisions by the Secretary of Defense, and/or by Congress, may require major program restructuring.

Finally, the year ahead authorizations are intended to give Congress a head start on the budget. Figure 4 shows that Authorization Committee hearings will begin in early fall, or concurrently with the PPBS budget review. For defense officials (including program managers) who are requested to testify, the preparation for testimony may cause competing requirements for their time and attention when budget decisions are being made and reclamas are being prepared. A mistake at this time, either during testimony to one of the committees, or during the budget review, can have a serious impact on a program's orderly progression over the next several years.

The net effect of advance authorizations is to increase considerably the workload during the budgeting phase of PPBS and to reduce to some extent DOD flexibility. The latter point is based on the fact Congress will be looking at authorization requests based on force level and program decisions made 27 months before the fiscal year is to begin. The new program decisions, just 3 months prior to the beginning of the committee hearings, may have to be tempered somewhat in consideration of the information already reported to Congress.

Problem #2

The Current Services Budget and PPBS

The Act requires the current services budget to be submitted to Congress by 10 November. To meet the deadline for the FY 77 current services budget, the Office of Management and Budget requested departments and agencies to submit their material by 15 September 1975. (Ref 12, p 5). Referring to Figure 4, three points regarding this procedure should be made. First, this date occurs before final Congressional action on the fiscal year, therefore changes are likely to occur between the time the estimates leave the departments and agencies, and budget submission in November.

Second, the submission of the current services estimates occurs before the budgeting phase of the PPBS. Therefore, as one informed source put it, "it will be based on summarized budget numbers available before submittal, but will basically be the Five Year Defense Plan (FYDP) numbers appropriately racked."

The third point is that apportionment of the new budget, that affects spending policies and therefore the current services estimates, should be completed before the estimates are submitted. Thus, it is likely that apportionment hearings will occur during August, as shown in Figure 4. For the DOD, this will probably be immediately after the latest PDMs are issued by the Secretary of Defense.

Problem #3

The Current Services Budget and Detail of Reporting

The level of detail to be reported in the current services budget could become a key issue in the future. As the new Budget Committees, and Congressional Budget Office staffs grow, and the other joint and standing committees become familiar with this new report from the President, requests for additional detail and supporting data are likely. If restraint is not exercised, the time and effort required for preparation could overload the system at a critical point in the budget process. The more detail required, the greater the involvement of the Services, and possibly, some of the key program managers.

To comply with this provision of the Act, OMB intends to submit the current services budget aggregated to the Appropriations Title level. Departments and agencies were requested to report levels of aggregation by individual accounts, or aggregates of accounts, at the highest level of aggregation that will provide budget authority and outlays for each of the following: agency total; major function/subfunction; federal fund/trust fund; controllable/uncontrollable; permanent authority/current authority; and appropriation bills. For DOD, the mid-October submittal was aggregated by title (eg. Research and Development, Procurement, etc.). (Ref 12, p 5). Under this policy, involvement of the Services is expected to be minimal.

Problem #4

House and Senate Budget Committees and Requests for Information

Because the Act creates two new Congressional committees that deal with the budget, it can be expected that the DOD will have to respond to additional requests for testimony and information. Both the House and Senate Committees have task forces that deal with the defense budget. Hearings are likely to be held prior to reporting the first and the second concurrent resolutions on the budget, as shown in Figure 4. Those held in February or March should not pose any special problem, although those held in August fall at a time when the PDMs are issued and apportionment hearings are likely to begin.

A big question at this time is, "to what depth will the new committees be going in reviewing the budget alternatives prior to making recommendations for each concurrent resolution?" One informed source pointed out that there is not sufficient time for the committees to review in detail the total federal budget. The hearings will probably deal with economic issues and very broad responsibilities. He felt that testimony from the Executive Branch would probably be limited to very high officials (e.g., the Director of the Federal Reserve System, the Director of OMB, the Secretary of Defense, etc).

A list of defense officials who appeared before the House and Senate committees during 1975, and the subjects of their testimony, reveals two key points. First, the subject matter in each case deals with very broad issues, and second, the witnesses in some cases were Service specialized. This second point is important because if the trend continues to more detail as the new committees become more firmly established, the requirements for the individual Services to appear may increase. If the depth and detail become too great, the new committees may begin to overlap into areas traditionally handled by the Authorization and Appropriations Committees. This will then create a heavy burden on the Services, and possibly some of the key program managers.

As a point of interest, one of the key issues during the development of the Act was the relationship of the new Committees on the Budget to the Committees on Authorization and Appropriations. In reading some of the testimony and background material on the Act, it appears that the intent is that the Budget Committees restrict themselves to broad economic policies, at the macro level, and not become involved with details.

Problem #5

The Congressional Budget Office and Requests for Data

The Congressional Budget Office (CBO) is authorized under the Act to secure data, estimates and statistics from the various departments and agencies of the Government. Thus, requests for additional data from this new office can be anticipated. It can be speculated that a large number of requests will be received after the current services budget is submitted. However, requests for data may be received at any time to support special studies the CBO may be conducting for one or more of the Congressional Committees, or during July and August when evolving 5-year projections for spending bills are being reported out of committee.

The depth and detail of these requests is not known at this time. In discussing trends (before the establishment of the CBO) one informed source noted that 4,180 pages of justification material had been submitted by OSD for the FY 76 Research and Development Account alone. This compares to 1,787 pages submitted for the FY 70 Account. It was pointed out that these figures do not include testimony or posture statements. Thus, the trend has been toward more detailed reporting and justification. Now the trend may be accelerated.

Problem #6

The President's Budget and 5-year Projections

As a result of the Act, the Congress will be looking at its budget responsibilities over a greatly extended time frame, during the budget process. The President's budget is now required to contain not only the budget estimates for the ensuing fiscal year, but also projections for the 4 years that follow.

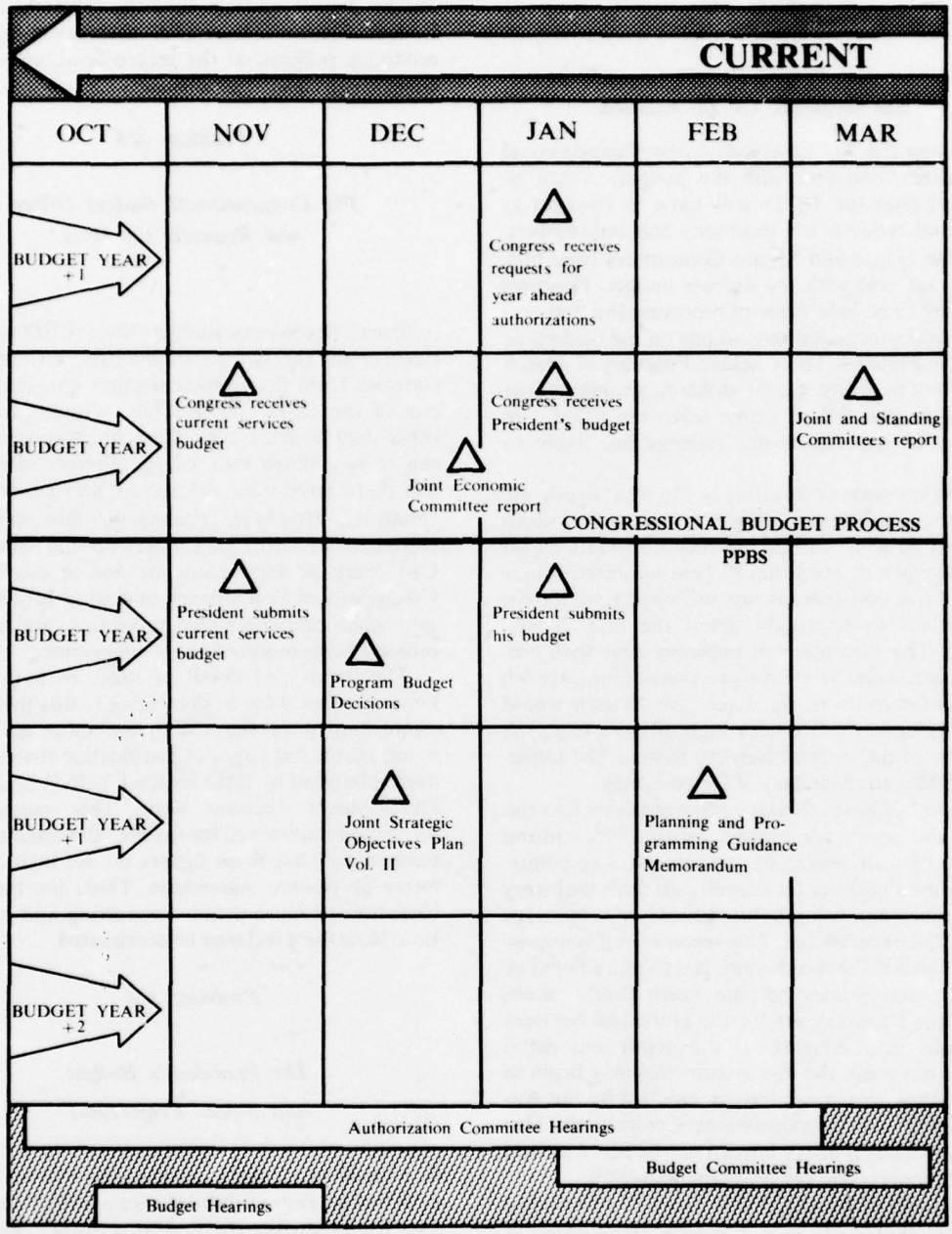

Figure 4. Calendar of Events for Three Fiscal Budgets

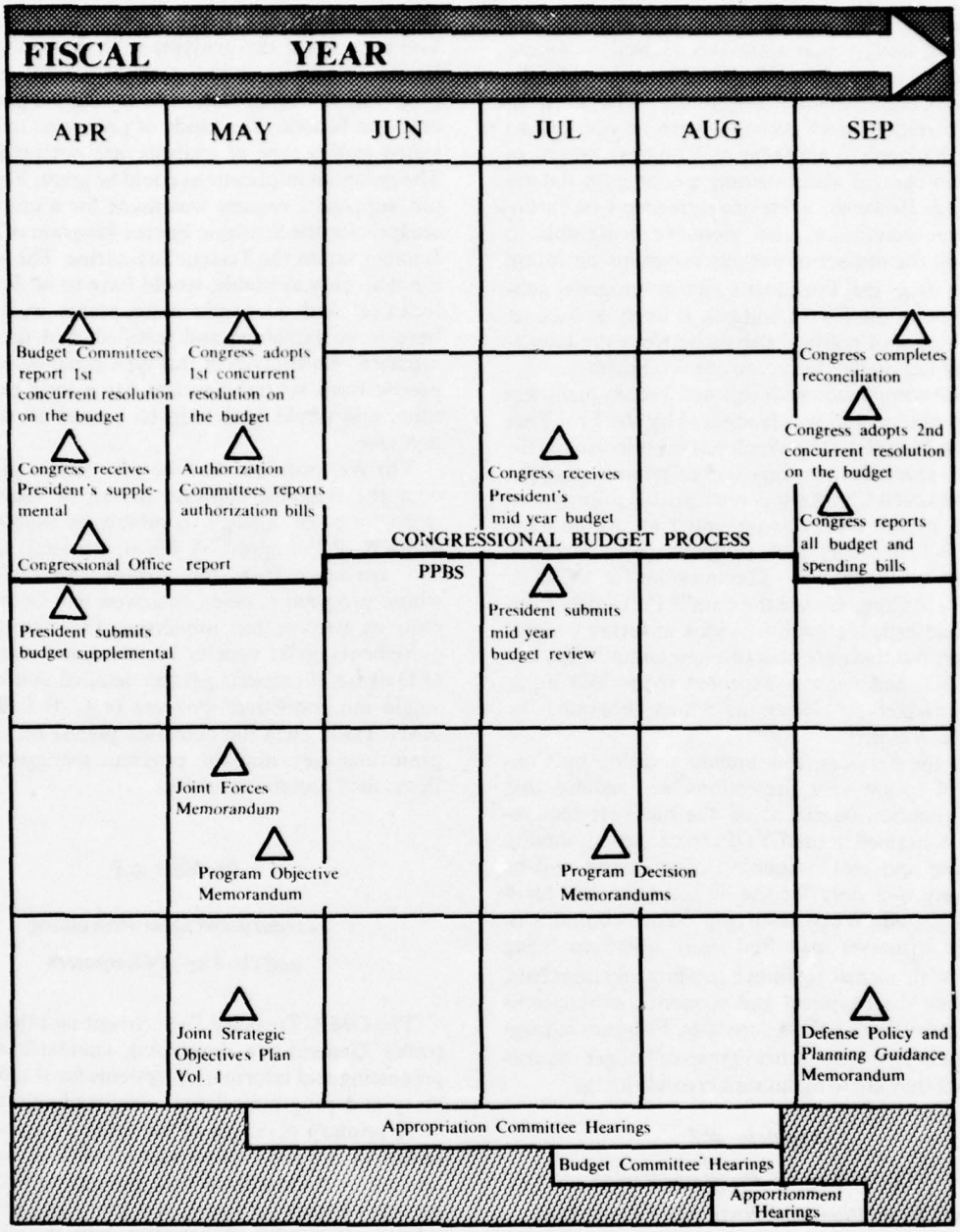

Figure 4. Calendar of Events for Three Fiscal Budgets

In addition, CBO will be performing analyses and preparing budget year estimates as well as 4-year projections of spending bills being considered by the various Congressional Committees. The need to make current budget decisions with an eye toward future budgets is apparent if Congress wants to maintain control while steering a course for federal spending. However, achieving agreement on future economic conditions, and therefore being able to agree on the impact of various programs on future budgets (e.g. the President's energy program submitted with the FY 76 budget), is likely to become another area of political debate between the Executive and Legislative Branches of government.

DOD compliance with this new requirement was not a problem, and was facilitated by the Five Year Defense Plan (FYDP) which has been in use for the past 13 years. In fact, one source pointed out that Congressional Committees were getting information related to the FYDP, aggregated at the package (e.g., B-1 Bomber) and program (e.g., Strategic Forces) levels, anyway. The question for DOD is: "How will Congress use the data"? Previously Congress had little inclination to look at future budgets in detail, but there are now two new committees, and the CBO, and each is expected to be looking at future budgets to determine which programs the nation can afford.

For the Services, this intense scrutiny by Congress of future year projections will require that more attention be placed on the out-year requirements contained in the FYDP. In particular, quality planning and cost estimating of programs will be necessary, not only for the budget year, but for 4 years beyond. When testifying before committees, Service witnesses may find more questions being asked with regard to future funding requirements, including the technical and economic assumptions used in developing these forecasts. Program managers will have to have a firm grasp of budget requirements if they are to maintain a credible image.

Problem #7

The Office of Program Review and Evaluation and Requests for Analysis

The Act authorizes Congressional committees to conduct analyses of government programs. Furthermore, it creates within the Government Accounting Office an Office of Program Review and Evaluation. The purpose of the analyses is to determine if the legislative objectives and goals of various spending programs are being met, or to measure a program's cost and benefit. The kinds of programs to be subjected to this type of analysis are not predictable. The potential implications could be great. For example, suppose a request was made for a cost-benefit analysis for the Strategic Forces Program of the B-1 Bomber versus the Trident Submarine. The analysis, if not already available, would have to be done. The technical and economic assumptions used would have to be explained and justified, and the results reported. An analysis of this type could tie up many people from several Services for a long period of time, and could lead only to a need to do more analysis.

The Act provides that the committees may conduct the analysis, contract it out, or request the department or agency to submit an analysis. Regardless of the approach taken, demands for data and assistance from the department or agency whose program is being reviewed will be made. If requests become too numerous, the reporting requirements could become burdensome. In the case of Defense, if requests get too detailed and begin to single out individual projects (e.g., B-1 Bomber, XM1 Tank, etc.) the demands placed on the program manager, and the program management offices, may become excessive.

Problem #8

Standardized Data Processing and the Use of Computers

The OMB, Treasury Department and the Comptroller General are developing standardized data processing and information systems for fiscal, budgetary and program-related data and information.

A primary objective of the OMB, Treasury Department and the Comptroller General is the development of standardized data processing and information systems for fiscal, budgetary and program-related efforts. Standardization will simplify data interpretation (i.e., provide for common bases) and permit meaningful comparisons of policies across departments and agencies of the government.

As with many provisions of the Act, the long-range implications of this provision can only be speculative. Discussions with several sources indicate the immediate concern is not how much data are needed, but what kinds of data are needed by Congress during the annual budget process.

Problem #9

The Budget Timetable and Apportionment

Apportionment normally precedes the beginning of the fiscal year by approximately 1 month. In the past this was usually in late May, or early June. With the new budget timetable set forth by the Act, only the first concurrent resolution on the budget and the authorization bills will have been acted upon during May. It is likely that apportionment could occur in August since by late August most spending bills should be approaching completion. If apportionment is deferred into September, for example, after all bills are reported out of committee, or after the second concurrent resolution on the budget is adopted, the effect may be to delay preparation of the current services budget. Accurate reporting of the current services budget requires that the fiscal policies and program levels for that year be known. In particular any planned deferrals or recisions of budget authority should be reflected in the current services budget.

If apportionment hearings are held in August, their relationship to PPBS and the Congressional budget timetable can be seen from Figure 3. As noted earlier, this will be a busy time of the year for DOD budget personnel and program managers. The Congress will be completing action on its spending bills. Reclamas to last minute changes may be required. The services will be preparing their budget estimates to be forwarded to OSD by 1 October, and authorization requests submitted the previous May will require update in preparation for committee hearings expected to begin in October.

Problem #10

Impoundment Control and Apportionment

The Act recognized that apportionment of appropriations is necessary and desirable when providing for a contingency, or effecting savings. However, the Act goes on to establish a method of reporting all proposed recisions or deferrals that might be imposed by the President or other federal officials.

The effect is to require the President to notify Congress of proposed recisions and deferrals of budget authority and to submit detailed special reports to both Houses of Congress and the Comptroller General. Congress may then consider the proposed recisions or deferrals, and concur or take appropriate action requiring the budget authority be made available for obligation. This new procedure is expected to greatly reduce the number of rescisions or deferrals proposed during a fiscal year, and will require a great deal more work in preparing the justification and back-up material to be forwarded to Congress in support of these proposals. It removes some of the flexibility enjoyed by previous administrations.

PART V

CONCLUSIONS AND RECOMMENDATIONS

A broad overview of the Congressional budgeting system and its implications toward defense is presented here. The full impact of the Congressional Budget and Impoundment Control Act of 1974 can be measured when the practices which mark its implementation are established. However, several conclusions may be drawn from this study.

First, the new timetable does establish fixed milestones that should continually focus attention on the need for timely completion of the budget process. The year ahead authorization submissions, and the current services budget should provide Congress with the head start necessary to reduce the need for Continuing Appropriations Resolutions. The timely enactment of the budget should assist defense officials, and program managers, in planning and executing programs for the fiscal year.

Second, the new timetable provides a structure, or framework, with many key points where defense officials, and program managers, can monitor the status of their programs as they move through the budget process. For example, the 15 March report of the views on the budget of the Standing and Joint committees may offer some insight into things to

come for the new budget. The 15 May reporting of authorization bills, and the adoption of the first concurrent resolution on the budget is a second key date. As the procedures become better established, the new timetable should permit earlier identification of those programs which are heading for trouble.

Third, Congress is taking a broader view of the budget and looking at longer time horizons. This requires better planning and cost estimating on the part of defense officials, and program managers. Two new budget committees, and the Congressional Budget Office, will be looking at budgets submitted by Defense. Thus, it will become important to minimize changes. These new organizations are expected to add heavily to requests for information and data.

Fourth, the new Congressional timetable will add significantly to the demands on the time of defense officials, and program managers, from August through November each year. Some new procedures, or organizational changes, may be required to ease the workload during that period of time.

Recognizing some of the limitations of this study, and some of its findings, several recommendations for future study can be made.

First, in a general sense, many of the potential problem areas identified earlier in this report should be revaluated. Many will require full implementation and several years of practice to fully evaluate. However, trends should be identified as early as possible.

Second, an in depth analysis of the current PPBS and its relationship to the new Congressional budget timetable should be conducted. Methods to ease the workload during the August to November time frame should be developed. Modifications to the PPBS or recommended changes to the Congressional timetable, should be considered to gain flexibility. The latter point may prove more feasible if a standard PPBS can be adopted within the Executive Branch and effectively married to a Congressional timetable.

Third, a more detailed analysis of the implications of this new legislation to the Services, and to acquisition management, is recommended. It is highly unlikely that the Services, and program managers, have yet been exposed to many of the changes that will result from full implementation of this Act.

In any event it is clear that the Congressional Budget and Impoundment Control Act of 1974 will test and rearrange many of the traditional methods of doing business.

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TECHNOLOGICAL PROGRESS IN ELECTRONIC COMPONENTS: A LIFE CYCLE SUPPORT PROBLEM

by

Mr. Carroll Eugene Garrison, Department of Army

How can a program manager reconcile the fact that, while his weapon system may have a life cycle measured in decades, important elements of that weapon system, especially the electronics subsystems, are being rendered obsolete through the rapid advance of technology, every three or four years? In this article the author, a graduate of PMC 76-1, outlines means of dealing with this problem.

An investigation of the adverse effects of the rapidly changing electronic component technology on the life cycle logisitic support of DOD weapons systems and equipment is reported in this article.

INTRODUCTION

The author's interest in this topic evolved from recent experiences in managing depot maintenance support for high-cost, low-density, special purpose communications equipment and tactical electronic warfare systems now used by the US Army and US Marine Corps.

The weapons systems and equipment described embody the highest state of the art current at time of manufacture, 10 or 15 years ago. They were the best available at the time but, in terms of circuit technology, today they are obsolete.

Technological change in the electronics industry is considered to occur with greater frequency than in any other field. One has only to open a newspaper or visit a department store to be aware of the rapid advances in electronic circuitry—advances evidenced by the pocket calculator and the interest in digital wristwatches.

A recent article in *Business Week* described the electronic semiconductor technology as having moved at "blinding speed." The same article states that semiconductor designers have, for several years, annually doubled the number of electronic functions fitted on a single "chip." Mr. Robert N. Noyce, Chairman, Intel Corporation, (the world's fifth largest producer of integrated circuits in 1975) forecasts another tenfold increase in complexity by 1980. (Ref 1, p 43).

Brigadier General Max Etkin, Commander, Defense Electronics Supply Center, in the July 1975 issue of *Defense Management Journal*, described the effect of the anticipated short technological life of some microelectric components on the support of DOD weapons systems as devastating – devastating in terms of the increasing numbers of spare parts required to be maintained in the logistics pipeline, the reluctance of industry to make large production investments, and the possibility that DOD will procure and stock repair parts that rapidly become obsolete. (Ref 2, p 45).

The program manager responsible for the acquisition of a new weapons system must be attuned to a changing environment. Major systems generally requiring 5 to 10 years from concept to deployment may, when fielded, be critically dependent upon outmoded technology. Within a few years, industry may no longer produce the items necessary for logistical support. Once the initial spares in the pipeline are depleted, reprocurement may be extremely difficult and costly.

The Department of Defense has a large inventory of equipment dependent upon vacuum tubes and components that reflect early transistor technology. This materiel will continue to be useful while repair parts are available. But the problems associated with support of equipment rendered obsolescent by advancing technology are becoming more and more evident.

LIFE CYCLE

SUPPORT PROBLEMS

CASE HISTORIES

A review of specific areas in which accelerating technology has resulted in item discontinuance or a manufacturer's reluctance to continue production of electronic components needed for existing equipment and weapons systems follows. The circumstances encountered and recorded are typical.

DECLINE IN

RECEIVING TUBE PRODUCTION

On January 15, 1976, RCA Corporation announced its intention to close its Harrison, New Jersey receiving tube plant by July 30, 1976. The press release stated that the plant closing "reflects the sharp decline in demand for receiving tubes in the face of the continuing shift to solid state devices in consumer, industrial and defense electronic systems." Also cited was the fact that RCA is presently the sole source for 110 types of receiving tubes. (Ref 3, p 1).

In earlier anticipation of the declining sources of vacuum tubes, the Deputy Assistant Secretary of Defense (Installations and Logistics) for Production Engineering and Materiel Acquisition, by memorandum dated 8 May 1973, requested that each military department and the Defense Supply Agency participate in an assessment of electronic equipment employing vacuum tubes. The DOD Ad Hoc Vacuum Tube Support Group was established in May 1973 to:

- Identify specific tubes now out of production or in short supply, and those tubes anticipated to be in this position in the future.
- Determine equipment applications, projected equipment life, and the rate of tube replacement.
- Develop practical and economical alternatives to the worsening problem of diminishing production sources for replacement tubes.

In the final report issued by the Ad Hoc Support Group in June 1975, the impact on the overall Federal Government was, in general, described as follows;

"... The Department of Defense and the civil agencies of Government have a large inventory of tube powered equipment that will operate satisfactorily as long as replacement tubes are available. Funds for modernizing or replacing this equipment are unlikely to become available in the foreseeable future in this period of severe budget austerity. With the disappearance of the market for tubes for the original equipment manufacturer, the replacement market

is insufficient to support profitably all of the vacuum tube manufacturing companies. This problem is acute in the area of receiving tubes. No more than half a dozen of the approximately two dozen major tube manufacturers that existed 20 years ago survive today.

The last important market for receiving tubes was the consumer home entertainment products industry. As recently as 1966, an enormous sales volume of receiving tubes was assured by the makers of color television sets and stereophonic reproduction equipment. Some manufacturers included as many as 28 tubes per set as an indicator of "quality." Since the appearance of the 100 percent solid state home entertainment equipment designs, the original equipment receiving tube market has, essentially, disappeared. Based on previous experience, industry sources have forecast a similar decline in the replacement market within the next 8 years...." (Ref 4, pp 3,4).

The Ad Hoc Support Group analysis of the vacuum tube industry, developed through visits to the manufacturing facilities of three major receiving tube producers, is summarized below. (Ref 4, pp 17, 18).

Lost Economy of Scale. The economies of scale that resulted from a mass market were being lost. Tube prices were escalating rapidly because certain irreducible fixed costs had to be spread over a rapidly declining sales quantity.

Parts Availability. Contractors suffered parts availability problems. In some cases only a single supplier remained to furnish vitally needed components. Offshore sources had to be utilized when domestic sources no longer existed. Subcontractors to the tube industry also suffered from rapid excalation in costs as sales volume diminished in relation to the fixed costs of operation. Yet, despite price escalation, few in the industry report adequate profits.

Industry Consolidation. Each member of the industry is attempting to consolidate to survive. Plants are being shut down, equipment moved or sold, employees furloughed. One plant visited had a factory work force that averaged 28 years of company service per employee and no factory employees having less than 17 years of company service. All less senior employees had been laid off. Normal attrition of personnel (through death, disability, and retirement) coupled with layoffs means that needed critical skills are being lost. There is little hope of training replacements.

Each of the major tube manufacturers is an operating division of a corporate conglomerate. The decision as to the continued existence of marginally profitable tube manufacturing operations emanates from corporate headquarters. Many expressed concern that operations that do not meet corporate standards of profitability would be closed.

Proprietary Planning. Industry disarray is aggravated by lack of coordinated planning. "long range" planning is considered proprietary information because of the marketing advantages a competitor would have if he knew another's future intentions. There is little advance notice of any action that would erode one manufacturer's remaining market to the benefit of another. Further, joint actions undertaken by competitors would likely be in violation of the Anti-Trust Statutes.

Among the results of the Ad Hoc Support Group efforts were findings that:

The Defense Electronic Supply Center (DESC) managed a population of 941 different types of receiving tubes (at time of the 1973–74 study).

A manufacturing source survey of all known domestic tube manufacturers determined that 241 of the 941 types of receiving tubes managed by DESC did not have a current manufacturing source.

Efforts to determine end item application and to forecast remaining life of equipment (including equipment furnished under international security agreements) were inconclusive. The equipment used vacuum tubes specified in a list of 136 "nonprocurable" receiving tubes. Data did indicate tube applications described as ranging from obsolete test equipment to first line military weapons system hardware. There was no discernable pattern for use, trend toward equipment obsolescence, or plan for orderly replacement. (Ref 4, p 23).

Displacement of the receiving vacuum tube is inevitable; but as stated by the Ad Hoc Support Group, a number of systems and items of equipment now in the useful inventory are dependent upon continuing sources of supply for repair components.

The effects of this "displacement" on the users may be considered characteristic of the demise, resulting from technological change of any product.

ANTICIPATED DECLINE IN TUBE-RELATED PASSIVE COMPONENTS

The decline in use and production of vacuum tubes is expected by the Government to lead to difficulties in the procurement of passive devices. These are items such as capacitors, resistors, transformers and relays designed for use at the voltage and current levels characteristic of vacuum tubes. With the disappearance of the market for tubes the replacement market for passive devices may not be sufficient to justify high levels of continuous production. The end result will be increased difficulty in supporting currently fielded systems and equipment.

THE MATURING OF A WEAPONS SYSTEM

An analysis of a "mature" weapons system, the Fleet Ballistic Missile System (POLARIS), was performed for DOD by the Logistics Management Institute with a view toward improving support programs. The final report, issued in February 1972, concisely defines the problem:

> **"...The nature of the material support problem for a weapon system changes as a weapon system matures. During the initial operating period producers of system hardware and associated repair parts are in their best position to furnish "bit and piece" material needed for maintenance. As the weapons system matures, however, production capability for some items may wither, or even disappear. Such a loss may result from a diminishing market or from technological changes that make previously produced items obsolete. These circumstances have proven to be especially true in the electronics industry, where the rate of technological change generally is regarded as being faster than in any other segment of technology.**
>
> **Some weapon system managers feel the effects of advancing technology more than others. The impacts depend to a large extent on their configuration control policies for their systems. The greater the depth of system configuration the more acute the problem of material support becomes as technology advances.**
>
> **The Fleet Ballistic Missile System configuration is controlled to the piece part level on electronic items. It is a mature system, particularly with respect to the POLARIS missile. The impact of technological change upon material support of the system electronics has become severe. Loss of production source is troublesome, and considerable effort is expended in finding new sources for the older electronic items in use. The entry of new items into the defense supply system and subsequent efforts to specify standard items from among those in the system, has imposed a heavy burden upon the Strategic Systems Project...." (Ref 5, pp 1, 2).**

INTERRUPTION OF SEMICONDUCTOR MANUFACTURING

Advancing technology is one of the factors (along with contract termination, increased industrial and commercial markets, or sheer proliferation of types of semiconductor components) that may result in the production termination of a particular component. As a consequence when at a future time the Government seeks to procure identical components to support existing systems, obstacles are encountered.

Deleterious effects of interrupted production have been found to include:

- The process cannot be repeated with sufficent accuracy to reproduce earlier product characteristics.
- Key personnel are lost or "detrained" with the result that disciplines for high quality must be restored.
- Specifications do not precisely define the process. Restart requires engineering development to provide an equal but new process.
- Materials and equipment of manufacture are modified or replaced.
- Contamination levels can be significantly different at restart of production.

- Process control equipment and methods are different in subsequent production runs.
- Screening techniques rely on uniform population of parts for effective segregation of unreliable parts.

The consequences of attempting to restart integrated circuit production, after it has been terminated, include: substantial start-up costs, rebaselining costs, capital equipment costs, training costs, and the impact and delays resulting from restart of a production line.

Minimum order quantities are usually required to support high reliability. Effects of restarts extend beyond the integrated circuit manufacturers as the subcontractors providing raw materials must also restart. The significance of this problem is emphasized by the fact that specific integrated circuits sought may be essential to major weapons systems such as POLARIS, MINUTEMAN, SAM-D, POSEIDON, APOLLO or other vital programs.

The fundamental advantage of using an IC is reliability — typically at least two orders of magnitude more reliable than discrete devices. One technical publication cites a failure rate of .005 percent per 1000 hours for a typical integrated circuit, or a mean time between failure (MTBF) of greater than 20 million hours. The reasons given for such reliability include a 90 percent reduction in wired connections (one of the greatest causes of circuit failures) and the ability to stand greater shock because the mass of any given part is so small. The use of redundant techniques makes even greater reliability possible in an IC. Because of the small size and low power dissipation, more than one component can be used for each function so that a failure of one component does not appreciably affect the entire system.

ECONOMICS: THE DRIVING FORCE

Problems experienced by DOD in acquiring repair parts may be attributed in part to a declining lack of DOD influence on the electronics components industry. One estimate is that, in 20 years, DOD has slipped from being a user of 90 percent of all parts production to being a 10 percent user, while commercial users have increased. (Ref 2, p 45).

The prime motivator of the US electronics industry today is maximum returns generated by whole new markets created through infusions of new technology and concentration on the consumer markets.

The emphasis in capturing markets through technological innovation is closely linked to the manufacturing techniques used to produce integrated circuits. Tooling costs may be the same for manufacturing one or ten thousand circuits, and in fact, as many as ten thousand devices are often processed together. The economies of scale add to difficulties in obtaining complex, low-volume circuits for weapons systems as these circuits cannot be fabricated economically.

DEPARTMENT OF DEFENSE POLICY

Department of Defense (Installations and Logistics) is staffing, with the military departments and the defense agencies, a proposed Department of Defense Directive on the subject of *Diminishing Manufacturing Sources and Material Shortages.*

The basic purpose of this directive is to insure that timely action is initiated within each DOD Component when essential end item production capabilities appear to be endangered by the loss of manufacturing sources or by material shortages.

The policies and responsibilities prescribed by the proposed DOD directive apply to problems resulting from advancing electronic component technology—especially in the area of diminishing sources for receiving vacuum tubes. A stipulation is that DOD Components will be required to implement procedures that will provide for mission essential support until the applicable end items have been replaced, modified, phased out of the inventory, or until there are sufficient item assets or manufacturing/supply capabilities to insure support through the forecasted end item life cycle.

One of the more difficult responsibilities levied upon the DOD Components is the requirement to develop a technique to identify "end item application" for critical or essential items affected by shortages or phaseout conditions. This opinion is supported by comments in the DOD Ad Hoc Vacuum Tube Support Group Final Report. This report

indicated that the DOD Components have difficulty in defining end item application and expected remaining life for vacuum tube equipment.

NOTE: The author is completely aware as indicated in the context of the article that the problem addressed is not limited to vacuum tube technology, nor even to electronic equipment. These problems affect all weapons systems to one degree or another and are a matter of growing concern within Department of Defense.

CHOICES FOR COPING WITH RAPIDLY CHANGING TECHNOLOGY

LIFE CYCLE COST AND TECHNOLOGY

Those involved in systems acquisition are aware of the DOD emphasis on estimating total Life Cycle Cost (LCC). Life Cycle Cost is defined as the total cost of:

- acquiring the product
- establishing the necessary logistics base from which to deploy and use the product and,
- maintaining the product in operable condition over some prescribed period of time. In the case of major weapons systems, the life-cycle period may be as much as from 20 to 30 years.

In the past acquisition program managers have been accused of being concerned with system acquisition cost and not being adequately concerned with operation and support costs. Now, LCC must also be considered. Department of Defense Directive 5000.28 requires that operation and support (O&S) cost goals, as well as unit acquisition costs be specified, preferably by the Defense Systems Acquisition Review Council (DSARC) I and not later than by DSARC II. Trade-offs to establish the balance between acquisition and support will be necessary to minimize life cycle costs.

EFFECTS ON SYSTEM DESIGN

Program managers and contractors are faced with two questions. One, is the technology embodied in the system going to be supportable at any cost throughout its life cycle? Two, in the face of a high rate of technological change, what design and support criteria should be considered to insure future supportability of electronic components?

The first question alludes to the "case histories" discussed earlier. Once original stockage is exhausted, commercial sources may no longer exist. The financial inducement to manufacturers to restart limited production may not be great enough to interest producers when this return is compared with the financial returns being realized on high demand consumer goods.

APPROACHES TO DESIGN AND SUPPORT

Approaches to reduce the risk of weapons becoming unsupportable because of technical obsolescence may be:

Design to technology. Determine the state of technology to be employed, and build around it.

Design for technology. Make a conscious effort to design equipment so that technological improvements are readily incorporated with minor redesign and rework.

Maintain long term contractor support. Use the original contractor's facilities and know-how to obtain spare and repair parts.

Employ the warranty concept. The contractor warrants that the equipment furnished will operate in its intended environment in accordance with contractual requirements for a specified period. The technological implication of the warranty concept is that the designer must strive to achieve a level of reliability that will minimize item return for service.

Include designs that must be supportable by the contractor at a future date (under the warranty.)

Emphasize standardization. Standardization can greatly reduce acquisition and life cycle costs.

Precise solutions for future problems are not available today. However, the recognition of typical problems inherent in accelerating technology, and the application of certain planning and design techniques may reduce future impacts on life cycle support.

DESIGNING TO TECHNOLOGY

Designing to technology is a concept of holding some aspect of technology constant, in anticipation of achieving long-term, life cycle savings through a wide range of acceptance, utilization and standardization. One effort toward standardization is described in the Navy Standard Hardware Program, November 1973, (later called the Standard Electronic Module Program). (Ref 6).

"...The Standard Electronic Module Program (SEMP) is an electronic module standardization program coordinated throughout the Navy by the Naval Electronic Systems Command at the direction of the Chief of Naval Material. The purpose of the SEMP is to make available a family of high reliability, low cost functional electronic modules that will reduce the cost and expedite the design and production of military electronic systems. By limiting the continual proliferation of electronic hardware developments, the logistical support posture of these systems will be significantly improved. The SEMP is achieving its objectives as demonstrated by dozens of equipment applications that span virtually all operating environments, resulting in the commitment to service of over three million SEMP modules. The concept of the SEMP does indeed work, being based upon the principles of limiting redundant design through the use of standard functions; and achieving cost benefits through consequent large production volumes and wide competitive availability. As the SEMP continues to gain further acceptance, the cost and performance benefits accruable to the Navy should become even more significant...." (Ref 6).

As only input and output functions are specified, a module may be "technologically independent" – the constant factor being the external configuration of the module. The internal components may be discrete devices or integrated circuits. The "design-to" aspect in standard electronic modules is that the end items of equipment are designed so that internal functions are performed by plug-in modules of a uniform size. Example: assume a basic module configuration; 2.62 inches wide, 1.95 inch high and 0.290 inch thick. In this hypothetical program are provisions for the use of larger modules of multiple span and thickness. Modules can be increased in span by increments of 3.00 inches and in thickness by increments of 0.300 inch.

The SEMP now comprises more than 250 module types, including digital logic, interface circuits, converter modules, analog modules, power supply modules and miscellaneous digital modules.

Life cycle support aspects of using standard electronic modules include:

- A discard-upon-failure philosophy, eliminating the need for maintenance facilities, personnel, test equipment, etc.
- Use of functional specifications that make standard modules nondependent upon a specific internal design, manufacturer or level of technology.
- Wide use of the modules to reduce the inventory of module types in the federal supply system and, as a result of high volume procurement, reduce spares costs.

The SEMP does not attempt to satisfy unique or unusual hardware requirements. The majority of the potential cost savings are not realized on such items. The SEMP is not in a "make it smaller and denser" race, but is concerned with providing standard modules capable of providing flexible functions at a cost that permits modules to be thrown away upon failure.

Literature available relates benefits from the use of standard electronic modules to all phases of the equipment life cycle.* Use of the modules may not be appropriate for all programs, but the Navy position is that the potential advantages should be considered and applied where economically and technically feasible. Navy publications pertinent to the SEM Program and its implementation are listed under "Additional References."**

DESIGNING FOR TECHNOLOGY

In considering how to cope with expected technological change when designing a new piece of equipment, certain decision criteria must be considered, for example:

Will the original design permit such a high MTBF that the item will last throughout its expected life cycle without requiring repair? (One problem with this condition is that actual usable life is always extended.) If a repair part is needed in the future, does the supply system have to provide the exact replacement part? If the exact replacement part or equivalent is not available (within acceptable cost and schedule constraints), can a new equivalent functional module be engineered for the system? Prior to re-engineering an equivalent module, an assessment must be made. The need for updating (item expected life in the inventory) must be of sufficient magnitude to merit actually committing resources to the process of design, distribution of modification kits, installation and other costs related to new item entry.

After spending approximately 50 years in a world of vacuum tube technology it is difficult to think of a technology turn-over occuring within 2 years. The entire federal logistic system is geared to providing replacement component support (piece parts) for years in the future, while to quote Robert L. Drake:

> **"...Newer technologies are enabling increasingly desirable circumstances for "no repair" (i.e outright replacement is cheaper than repair) decisions based on logistics economics – and increasingly the newer technology items are becoming less capable of being repaired regardless of the economics involved...." (Ref 7).**

Everyday examples of commercial progress toward "no repair" decisions include the transistor portable radio and the pocket calculator. The portable black and white television set is probably close, if not already at that decision point now.

One current example of an item of electronic equipment specifically manufactured to accommodate circuit changes resulting from advancing technology is the ARC-164 radio, designed for the United States Air Force by the Magnavox company. William H. Boden states:

> **"...The primary effort in designing the ARC-164 was to take an existing modern radio design, the ARC 150, and revise it for the express purpose of winning a production contract competition with lowest LCC as a major criteria for award. No significant changes from the original radio were required solely for the sake of meeting new performance specifications. Fortunately, the basic ARC-150/ARC-164 design has inherent LCC advantages provided by its unique "slice construction....**
>
> **In addition to the obvious advantages, additional LCC benefits are realized by complete elimination of the conventional radio chassis, the addition of the protective frame around each slice, and the simplified future growth potential afforded by the addition of slices. For example, if technology advances made in the next few years permit significant improvement in performance or reduction in complexity in the transmitter, then the independent transmitter "slice" alone, rather than the whole radio, would be redesigned and replaced...."* (Ref 8, p 33).**

*Mr. John A. Wyatt, DNC, developed a comprehensive Defense Systems Management College Individual Study Program Report entitled, "Standard Electronic Modules: Their Impact on Life Cycle Cost" during PMC 74-2. Program managers interested in detail regarding the SEMP and its possible application to their programs should consult the study report or the proponent activity, the Naval Electronics Systems Command, Attention: ELEX 5043, Washington, DC, 20360.

**The specifications and standards covering the design, procurement and application of standard electronic modules are now being coordinated for interservice use. The draft of MIL-STD-1634, "Module Descriptions for the Standard Electronic Module Program; Project Number MISC-0B14" has been staffed by Defense Electronics Supply Center to Army, Navy, Air Force and allied activities for review and comment. A publication date of June 1977 is anticipated.

*A readily removable and replaceable plug-in electronic component part.

MAINTAINING LONG-TERM CONTRACTOR SUPPORT

One technique proposed as a solution to maintaining support of weapons systems once they are phased out of production is the initiation of a Supply Production Continuity Program.

A Supply Production Continuity Program, can be a jointly planned effort to provide life cycle support for out-of-production equipment. The main objective is to provide a cost-effective solution to the spares and repair needs of a weapons system by utilizing the original contractor's facilities and know-how. Cost and lead-time savings result from such a program. In addition, other advantages can be realized such as preservation of management and technical expertise, improved mobilization planning, maintenance of system quality and reliability, more efficient facilities loading, and faster reaction to emergency requirements. (Ref 9, p 64).

One application of this concept was the support of a US Navy airborne radar. The contractor was providing substantially identical support to both the US Navy and a foreign government. The support to the Navy was accomplished via two annually renewable basic ordering agreements covering spare parts production and a repair program.

Of interest is one aspect of the support contract between the foreign government and the contractor that included implementation of a direct purchase agreement for non-Federal Stock Numbered and out-of-stock items. (Ref 9, p 65). While the desirability of prolonged dependence on contractor support for US military weapons systems is subject to much discussion, the use of such support for out-of-production equipment places the burden of maintaining past-technology equipment on a contractor (for a price). The US Government logistics system is thus relieved from having to stock and supply electronic components no longer compatible with the equipment in the US inventory. The concept may have considerable merit, if not otherwise affected by political implications, in carrying out US logistics obligations under international security assistance programs.

Supply Production Continuity arrangements may be expected to be encouraged and favored by firms that are defense-oriented.

THE WARRANTY CONCEPT

Reliability Improvement Warranty (RIW) procurement is currently under consideration by DOD activities as a technique for committing production contractors to a specified operational reliability and for reducing life cycle costs. Application of RIW procurement may, in some cases, reduce problems resulting from technological change.

The RIW commits the production contractor to perform depot repair services at a fixed price for a specified duration of operating time, calendar time, or both.

> **"...If a contractor is committed to perform repair services on his delivered equipment for an extended period of time at a fixed price, he has strong incentive to achieve or exceed the reliability level upon which the warranty price was determined. If during the initial period of the warranty, an unexpected reliability problem is discovered, there is strong incentive for the contractor to introduce a no-cost ECP to correct such a problem so as to reduce the number of future repair actions over the remaining warranty period...." (Ref 10, pp 108,109).**

The technology aspects of RIW are directly related to equipment reliability. To maximize contractual benefits, contractor reliability design efforts must seek to minimize the expected number of returns for service. The technology of components must be such that either a minimum number of failures are likely (i.e. high MTBF), or if a component fails, the manufacturer must be able to provide and install a replacement. It is likely that, under a RIW program, the contractor will give additional design consideration to the long-range supportableness of his equipment.

STANDARDIZATION

Increased use of reliable standard components, especially those supported by a large commercial production base, can be a significant factor insuring

life cycle support. Attempts to achieve performance levels at the upper edges of the state of the art encourage the use of specialized devices, not subject to economies of high volume production. Recognition is given the fact that some programs, such as missile systems and satellites, require extreme levels of reliability that may warrant the limited manufacture of high precision electronic components. Whenever feasible, standardization procedures for electronic components should be applied. The trade-offs involved weigh heavily in favor of effective life cycle support.

> **Standardization, on a big program or a small program, on a defense program or a commercial program, provides many interrelated advantages. These advantages include:**
>
> - **Reduced item cost through use of readily available items,**
> - **Reduced assembly and installation costs for items (as a result of standard tooling),**
> - **Predictable reliability through use of items with established service histories,**
> - **Reduced numbers of total types of items requiring initial procurement and subsequent logistics systems,**
> - **Improved maintenance by elimination of odd or unusual items, and**
> - ***Reduction of testing and qualification.***
>
> **All of these factors add up to improved potential for meeting schedule and cost goals through elimination of duplicative hours and costs required for development and use of similar items. (Ref 11, p 18).**

Another benefit of standardization is the reduction in nonstandard or limited application components that must be maintained in supply systems. The Defense Supply Agency (DSA) has established Military Parts Control Advisory Groups (MPCAG) who have the function of encouraging the defense industry to use military standard components already in the inventory, where possible. Efforts by the MPCAG at the Defense Electronics Supply Center (DESC) Dayton, Ohio, are shown to have achieved some success. (Ref 12., p 50).

> The situation in semiconductor microcircuits prior to the intervention of MPCAG typifies the previous costly proliferation of nonstandard components.

Although different avionics companies buy functionally similar types of microcircuits, each company may write a different specification and specify slightly different performance parameters and test conditions for the microcircuit manufacturer. When the weapons or avionics systems involved go into the military inventory, DESC must assign a different Federal Stock Number (FSN) to each of these seemingly different microcircuits and must then buy, stock and handle a supply of each. The cost to the government of assigning an FSN and maintaining each part number – excluding the cost of buying spare parts – is conservatively estimated to be $1,200 per part number over a 10-year life-cycle period.

The supply bins at DESC now hold some 16,000 different microcircuits - different in terms of Federal Stock Number. One analysis indicates that the same electronic functions probably could be performed by 1,000 standardized microcircuit types.

The USAF was the first service to try to achieve some electronic component standardization in new weapons systems (in the late 1960's, before the creation of MPCAG), and assigned the function to DESC. Because of the fast-moving state of microcircuit technology, attempts at standardization of microcircuits were not made *until the USAF/McDonnell Douglas F-15* Program.

For one widely used type of microcircuit, the linear operational amplifier, DESC had 80 different configurations (FSNs) in stock. Without the effort at microcircuit standardization, it was estimated that another 84 linear operational amplifier configurations would be needed in the DESC inventory to meet the needs of the F-15, the USAF/Fairchild A-10, the Rockwell B-1 and the Boeing E-3A (Airborne Warning and Control System). Instead, through the MPCAG efforts, 20 operational amplifier configurations were standardized that can meet the needs of the above aircraft programs. These 20 standard configurations will eventually enable replacement of the 80 nonstandard operational amplifier microcircuits that must now be stocked and handled. (Summarized. See Ref 12).

Thus, 20 standard microcircuits of this basic type have replaced or will replace what would otherwise have been 164 different configurations.

Aside from the logistics costs savings to the Government, there are indirect savings when contractors can use standard components. Special drawings and test procedures need not be prepared and special reliability tests, are not necessary. The semiconductor manufacturer benefits by being able to achieve longer, and steady production runs on fewer different microcircuit types.

Another source of standard component data is the Defense Integrated Data Systems (DIDS). (Ref 13). When fully operational, DIDS will be able to rapidly provide information concerning onhand, standardized parts having potential application in meeting specific requirements of new designs. The DIDS will provide the equipment design community with the capability for direct DIDS interrogation by part number or item characteristics. The output will consist of a list of standard items, to be considered by the design engineer, that exactly or nearly match the desired part characteristics.

A cross-reference is provided of nonstandard item part numbers and National Stock Numbered (NSN) items. In this manner, future interrogations for the nonstandard part will receive replies cross-referenced to the standard item.

A cross-reference of engineering drawings to the item part number is furnished so requestors can quickly determine proprietary status, availability and the agency where the drawings can be obtained.

User and supplier information regarding the availability of standard parts is supplied, together with the Government assigned unit price for design-to-cost considerations.

This is not to say DSA MPCAG and DIDS will solve all acquisition and life cycle cost problems. These programs are only two management tools available to contractors and the military departments.*

SUMMARY AND CONCLUDING REMARKS

Development of this article included a review of technological progress and resultant problems in a limited group of active electronic components; specifically, vacuum tubes, transistors, integrated circuits and microprocessors. These components may be considered as the basic "building blocks" of any electronic system, regardless of where the system is used or what purpose it serves.

Consideration of the elementary building blocks, and the technology on which they are based, can be used to gain an insight to the total problem of coping with technological change. An understanding of the rate of technological change and its present impact can be used to gain an appreciation of potential future problems.

Successive generations have not yet totally displaced preceding technology. Requirements for certain types of vacuum tubes and individual transistors still exist today. In cases where successive generations do displace earlier technology, the results generally are manifest by devices that do many more electronic functions than their predecessors, yet require a smaller package.

The current emphasis, among leading semiconductor manufacturers, is on the manufacture and marketing of microprocessors. The lucrative consumer markets include increased use of such circuitry in microwave ovens, clothes washers, dishwashers, TV and radio receivers, and automobiles. Industry estimates for sales growth in 1976 fall in the range of from 20 to 30 percent. (Ref 14).

For several years, semiconductor designers have annually doubled the number of electronic functions fitted on a single chip. A most impressive new product of 1975, the "4K" memory, storing 4,096 "bits" of computer data on a 1/4 inch square silicon chip, is equal to 14,000 individual transistors, and is already "last year's" model. Even before the 4K reached high volume production, the Intel Corporation was expected to announce a 16K model, having four times the capacity of the "older" type. (Ref 15, pp 1-5). Forecasts for 1980 envision chip capacity of 65,000 bits.

The principal factors contributing to technological change in electronic components include:

- *Economic Motivation:* The creation and exploitation of new markets, especially for consumer goods. All other factors are actually functions of economic motivation.

* The authoritative sources of additional detail on standardization are Department of Defense Directive 4120.3, "Defense Standardization Program," and Defense Standardization Manual 4120.3M, *Standardization Policies, Procedures and Instruction.*

- *Manufacturing Innovation:* The production of increased quantities at lower costs, combined with the ability to produce a device having greater capacity, yet requiring less space or power than the preceding model.
- *Increased Reliability:* Successive generations of devices, especially semiconductors, are leading to the time of "no repair" decisions, or the possibility of zero failures of a component during a system's life cycle.

The resultant effects of the factors cited upon the life cycle support of DOD systems and equipment include:

- *A Diminishing Source of Resupply.* As industry advances to newer, more lucrative markets the size of the underlying commercial production base, traditionally a support for defense needs, decreases.
- *Lack of Significant DOD Influence on the Electronic Components Industry.* The governmental influence achieved during World War II on production and technology has been replaced by consumer and business demand.
- *Manufacturing Innovation.* Manufacturing innovations, especially in size reduction and packaging techniques result in requirements to stock a proliferation of different types, shapes and sizes of components. Applications of such a variety of components are limited and dependent upon the generation of components exemplified by the state of the art at the time of end item design.
- *Maintenance and Logistics Concepts Are Affected.* Support concepts require review and revision as devices having characteristics of "no repair," or extremely long MTBF, result from increasing reliability.

The suggestions presented are ranked in a recommended order of preference for use as planning and design criteria:

- *Standardization.* Use standardized components where possible and take advantage of what commercial production base there may be. Avoid pushing to the fringes of the state of the art in components; the components may not be supportable in the future.
- *Design for Technology.* Consider equipment designs adaptable to future modification and rework, if justified by technology breakthroughs and the remaining useful service life of the equipment.
- *Design to Technology.* In the case of the Navy SEM Program, overall success is dependent upon both wide acceptance and mass production of functional modules. Until such time as the use of these standard modules becomes attractive to commercial application, the military services are in a sole user position. While the manufacturing costs of SEM may never achieve "economies of scale" realized by other components that have wide commercial use, the life cycle impact on inventories and maintenance procedures are favorable.
- *Maintain Long Term Contractor Support.* Contractor support is not favored for primary weapons systems or combat equipment. It may suffice for support of International Security Assistance or Foreign Military Sales (FMS) cases, thereby relieving US logistical systems of the obligation to provide continuing support for equipment no longer in the US inventory.
- *The Warranty Concept.* The Warranty Concept is highly questionable at this time owing to the newness of the concept. Reliability Improvement Warranty procurement remains as one area of possibility in managing technological change.

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TRAINING WITH INDUSTRY

A FINAL REPORT

by

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What might a military acquisition manager learn during a tour of duty as a member of an industry program management team? The necessity of keeping schedules? The desirability of avoiding management by consensus? The value of concurrent Producibility Engineering Planning (PEP) and Engineering Development (ED)? To share valuable insights into lessons learned during a year with industry, read LTC Ammerman's final report on his tour with the Martin Marietta Aerospace (MMA) Corporation.

INTRODUCTION

On 11 June 1975 I reported to the Orlando Division of Martin Marietta Aerospace (MMA) to participate in a 1-year Training With Industry (TWI) program. With the understanding that I was, in effect, to become an MMA employee, the company and I set out on a program aimed at developing in me a thorough understanding of materiel acquisition from a defense contractor's point of view. I established an additional objective for myself, that of explaining to MMA the variables as seen from the defense establishment standpoint, insofar as my 3-year Pentagon experience would allow. The concept of the TWI tour being a two-way street has been the key to reducing the traditional barriers to a free flow of information between government and industry personnel.

The year's tour was a complete success. One of the two most significant events contributing to its success was the attitude taken by Mr. Sidney Stark, then Vice President and General Manager of the

Orlando Division. Mr. Stark made it clear at the outset that I was to be treated as a management level employee, and that I was to be shown the inner workings of the organization through open doors. Through implementation of this policy I gained significant insight into the interplay of the variables that impact civilian industry management decisions. The second major event that contributed to the success of the program was my primary assignment as Assistant Program Manager on the COPPERHEAD (CLGP)* development team. The Engineering Development Contract was awarded to MMA by the Army on 25 July 1975, shortly after my arrival on station. I served in this assignment for the majority of my tour and was able to observe and be a part of the day-to-day activities and decisions of Mr. Leonard Wroten, the COPPERHEAD (CLGP) Program Manager. Mr. Wroten, a uniquely talented and extremely capable manager, devoted many hours to ensure that I was exposed to, and understood, the many facets of his job as the contractor's manager for this Army system. Without a conscious effort on his part, the knowledge and experience that I gained from this assignment would have been greatly lessened. The willingness of Mr. Wroten to assign to me varied tasks that crossed functional lines and mirrored his own activities, resulted in my learning first hand of the many pressures that an industry program manager must face.

ACTIVITIES AT MARTIN MARIETTA AEROSPACE

The uniqueness of my role — that of a trainee with both responsibility and authority — took a while getting used to by a few of the MMA middle managers. This was probably a result of the normal wariness between government and industry personnel, but I was soon accepted by all as a real member of the MMA team.

* Cannon Launched Guided Projectile

During the first 6 months I spent much of my time helping to develop plans for the early fielding of COPPERHEAD (CLGP), plans for Army-Navy Engineering Development competition and recovery plans that would enable MMA to minimize the schedule and cost impact of an unexpected cut in the FY76 funding for the program. Many other work assignments were given me during the tour, including the development of negotiating positions for MMA teams developing major subcontracts; interviewing prospective team members; coordinating multifunctional tasks; "statusing" and expediting parts procurement for, and fabrication of, the COPPERHEAD (CLGP) laboratory prototype and aerodynamic shapes; participating in contractor development tests; and, following action items from various government and management reviews. The scope of work ranged from clerical tasks to strategy sessions with the General Manager.

After initial sessions with each MMA functional director, wherein I obtained senior management views on the roles of functional disciplines in a matrix organization, I spent about 7 months interviewing, observing, and working with middle managers in the various functional areas. This time was superimposed on my project duties, thus allowing me to continue work on specific tasks assigned by the COPPERHEAD (CLGP) Program Manager. At the same time I learned the detailed operation and responsibilities of the functional organization. My status as a TWI trainee allowed me to question procedures and rationale that normally were not subject to review across functional boundaries. I feel that the technique of exposing the trainee to functional thinking is vital to the program's success. A project's success orientation sometimes causes head-on collisions with functional concepts and procedures, and the only way to understand this is to work on both sides of the matrix.

During the year I attended management meetings at virtually every level from the bottom to the top of the MMA organization. These sessions included renegotiation of prime contracts, corporate management reviews, and staff meetings on day-to-day problems. In addition, considerable travel was necessary. I attended test integration working group meetings at the Army Project Office and an ADPA seminar on DOD program management in Washington; I briefed the Vice Chief of Staff of the Army (VCSA) on the TWI program; and I appeared before

the Senior Level Army Management Group chaired by Major General Philip R. Feir, Office of the Deputy Chief of Staff for Research, Development, and Acquisition (DCSRDA).

OBSERVATIONS

The following observations are based directly on my experiences during the past year with MMA, but are tempered by my 3 years of working in the Pentagon. Many of the points are arguable, but they represent problems that do exist in the materiel acquisition system today.

MAINTAINING SCHEDULE

If I had to select what I thought was the most important lesson I learned during my tour with industry, without a doubt it would be that a program must be kept to its schedule. Most serious problems seem to come about because some event or series of events does not take place on time. The first slip is just the beginning, because a delay of any significance has an unbelievable ability to pyramid. Unless aggressively attacked, many other schedule stretches will occur, and associated costs will compound the seriousness of the ensuing situation.

The problem of missing schedules is aggravated by what I feel are two fundamental deficiencies in our materiel acquisition system today: inordinately long development cycles, and management by consensus. Research and development programs are always going to be faced with the problems of meeting schedules, but the environment of today favors unnecessary slippage, and inhibits smooth recovery when a schedule has been blown. The development cycle has become so long that both government and industry plan poorly — partially because of the inherent difficulty of long range planning and partly because of attitude. The system has become used to the seemingly endless round of change that is a way of life in long-running programs. The penalty that the program manager must pay is great, because after the dust clears and the nearness of the next event forces detailed analysis and coordination, the schedule slips because the house is not in order.

The management by consensus environment, present in industry and government, prevents timely adjustment when a schedule is missed. I thought that the problem of strong independent program managership was unique to the bureaucratic environs of the government, but my tour in a civilian matrix organization has shown me that no real problem is solved there either, without the frustrating process of getting functional and management consensus. Seldom did a day go by in which I did not see an example of the delaying effect of decision-making by consensus. Our system has grown to demand agreement by all. We pay dearly for this process.

I have learned that a good program manager must spend a great deal of his time understanding his schedule, and looking for ways to cut the "uncuttable." Secondly, a good program manager must have the courage to make decisions in a timely fashion despite the pressure, and then argue his position, if need be, while the program continues down the road. I feel that industry has begun to realize that consensus costs money, and they, more than the government, have begun to expect their managers to make the controversial decisions and move out. True, industry can apply this method more efficiently than can the government in view of the complex system of counterbalances between interested agencies, but I feel the basic reason for government managers not exerting the same degree of independence as their counterparts in industry is that the government wants to manage by consensus. In my opinion, this situation contributes more to schedule delay than any other factor.

THE USEFULNESS OF COMPETITION

A second important lesson has been the recognition of the role of competition in the development and procurement process. First hand observance of the impact of competition, or the lack of it as the case may be, on both prime contractors and vendors has been a real eye-opener. The net result of what I have experienced has been the realization that there are times when competition is cost-effective, and other times when it is just plain costly.

It has become apparent to me that "second sourcing" vendors is a technique that could stand utilization — the possible return on investment is very great. The prime reason that this technique is not widely used is its cost. The DOD bidding process, to include the new "four step" procedure, continues to force buy-ins. Buying-in spells death to "second sourcing" vendors, and thus to controlling the costs of critical components built out-of-house. I have watched virtually every COPPERHEAD (CLGP) subcontract double in cost from proposal to signing. I am absolutely convinced, after having taken part in two of these negotiations, that "second sourcing" each of the items negotiated would have cost little, if any, more than we are now paying to go with just one subcontractor. The money to do this simply was not placed in the bid, because it would have forced the apparent costs too high. COPPERHEAD (CLGP) is not an exception. In my opinion, competitive pressure on vendors is lacking in almost all of our Army development efforts.

On the other side of the coin I feel that artifical forced competing of prime "system" houses is an overused technique. The cost we pay for carrying two giant overhead structures is significant, but often overlooked is the cost that we pay for the jockeying by a loser, or perceived loser, as he attempts to play catchup with the apparent winner. My experience in this area on the AN/TTC-39 was reinforced on COPPERHEAD (CLGP) — ultimately the government pays what the job costs. Competition among primes in early development makes little difference on later development costs. What competition between contractors can provide is confidence that technical problems will be solved. I believe that after this value is exhausted, so is the usefulness of competition among major primes.

PRODUCIBILITY ENGINEERING PLANNING (PEP)

The value of starting PEP simultaneously with the initiation of Engineering Development cannot be overemphasized. When PEP and design are not concurrent accomplishments, as in the case of COPPERHEAD (CLGP), the degree of risk that a program manager assumes when making design decisions escalates.

On COPPERHEAD (CLGP), industry and the government failed to recognize the need for an early PEP start – originally scheduling PEP turn on at 11 months into Engineering Development. The funding restriction forced the PEP start to be further delayed until the 15th month. As the effort evolved, it become apparent that the PEP function is critical if we are to attain the best producible design. Although the Design to Unit Production Cost (DTUPC) effort was outstanding, and design was close to the ultimate cost goal, the program manager was fully aware that as the full contingent of manufacturing engineers come on board more changes creep into the design. I have learned that a program manager must insist on early initiation of PEP, especially in the case of developments leading to high production quantities. Late scheduling of PEP increases the danger of encountering changes to facilitate producibility, and the consequential invalidation of testing of the earlier prototypes. The cost and schedule dangers are quite real.

DESIGN TO UNIT PRODUCTION COST AND THE AUTHORIZED ACQUISITION OBJECTIVE (AAO)

My advocacy of DTUPC has been somewhat shaken by the implementation of this cost control technique. The effectiveness of the DTUPC scheme is highly dependent on the government's ability to accurately predict both the AAO and the required production rate. The Army repeatedly fails to determine, early, a production quantity that it can both afford and defend against change. Our program managers must pressure the system with all their might to obtain a realistic procurement goal and policy as their system enters engineering development — not later.

The real need for such information is not well-understood. DTUPC depends on the right AAO, not because we are not smart enough to hedge against changes by employing learning curves in the contract, but simply because design decisions are made starting on day one in engineering development, and the validity of these decisions is vitally dependent on AAO and production rates. Learning

curves do not offer protection against making a design decision on erroneous data. I have seen case after case in the Pentagon where figures at the start of engineering development were ridiculously high.

My experience at MMA coupled with careful review of what I had seen in the AN/TTC-39 and SINCGARS (Single Channel Ground and Airborne Radio System) efforts convinces me that as we genuinely strive to get to a lower and lower DTUPC we may be negating potential gain-making decisions in favor of quantities and rates that will never be attained. Our real error is hidden by the fact that when we finally acknowledge affordability by buying the greatly reduced quantity, at stretched-out rates, we end up with a weapon or a radio that was designed to be cost effective for vastly different production quantities. A program manager must constantly be on guard to prevent this situation.

The fact that we chose advanced technology because its advantages may be superior for large procurements is never questioned, even when we severely reduce the procurement. The fact that we select plastic parts to gain tremendous savings at high production levels is never questioned, even when we stretch the buy to a number of smaller procurements, perhaps with several different prime contractors. Were these design choices right for the lower quantity? These questions are not asked, because by the time we settle on an AAO, the design is fixed. Here DTUPC hurts us, because we do not follow through with our procurement policy. Had we carefully judged at the outset the requirement and affordability we could have made it possible to develop a product fitted to our buy. Under present procedures, often we do not have a chance to get a proper fit, even though we achieve a low theoretical cost.

COMMENTS ON THE TRAINING WITH INDUSTRY PROGRAM

The experience I have gained in the TWI Program makes me feel quite strongly that the program managers of major Army programs should participate in a TWI assignment. Such assignment is a highly desirable prerequisite . for program managership.

ELIGIBILITY CRITERIA FOR TWI CANDIDATES

Based on discussion with various industry officials and military contemporaries, I suggest that we establish certain firm criteria for officers prior to committing them to a year of TWI training. TWI must be oriented toward developing program managers and key materiel acquisition managers. This approach is preferred, rather than an orientation aimed at developing a good green-suited engineer or cost analyst. I am not sure that the Army has really decided what it wants the program to do. If a managerial orientation is our aim, the TWI effort must use a base of senior field grade officers with Department of the Army, or equivalent, staff materiel acquisition experience. This is not now the case. Broad high level experience is certainly to be preferred if maximum gain is to be achieved from the TWI tour. Senior majors and lieutenant colonels should be the officers considered for TWI in that they are the only officers close enough to potential PM assignments to warrant training that is of a perishable nature. Industry and DOD procurement policies fluctuate, and if we are to fully capitalize on our investment in TWI officers we must utilize them to the maximum while their experience is fresh. These same officers with 14 to 18 years of service are experienced enough in management within the Army to be able to understand both sides of the government-industry materiel acquisition problem. I feel that an officer without such qualifications is at a distinct disadvantage in determining just what it is he should look for during his stay with industry. We cannot write a checklist for him – – he has to have a feel for the problems. If the officers are junior, I believe the tendency will be to develop tunnel vision, not because the officers selected aren't top drawer, but simply because their experience base is not sufficient.

FORUM FOR DISSEMINATION OF TWI EXPERIENCE

At present a forum is not available for the dissemination of the lessons learned by TWI experienced officers. Since relatively few officers will be trained

in the TWI program, it would appear highly desirable to develop some procedure for the dissemination of the lessons learned from this unique experience. One possible approach would be the assignment of TWI officers to the Defense Systems Management College (DSMC), either as students or as instructors, within a year of completion of their TWI assignment. This would be an excellent vehicle to pass TWI knowledge to prospective defense systems managers. This sequence, TWI assignment, then DSMC, is preferable because it allows the officer to understand the "real" world before he is exposed to the textbook approach. The technique would serve as another means of imparting current thinking to the curriculum of this important school.

SIZE OF THE TWI PROGRAM

The present quota of TWI officers, 15 per year, appears to me to be considerably lower than required if we are to have an adequate base of officer personnel tuned-in to the problems and perspectives of industry. The utility of the TWI experience is much greater than a hard science masters degree insofar as management development goes. I am glad I have both reservoirs of knowledge, but I will lean far more heavily on my TWI experience than my MSEE should I become a program manager. More officers should be given the opportunity to be exposed to industry thinking even if it means that we must trade off some of our hard science or other civilian education programs to provide necessary funding and remain compliant with the ceilings on student officer personnel.

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WHAT HAPPENED TO PERT?

by

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Reports of the demise of PERT have been somewhat exaggerated, say three officers at Wright Patterson Air Force Base. Their views on "What Happened to PERT"? hold a useful lesson for manager and other enthusiasts who are willing to believe that there cannot be too much of a good thing.

INTRODUCTION

In the late 1950s and early 1960s there was a significant growth of planning and control techniques designed primarily for use in managing complex projects. One such technique, that perhaps became the best known, was the "Program Evaluation and Review Technique," or simply PERT. Primarily owing to the great success of the Polaris program where PERT was first applied, PERT became a widely discussed and publicized technique. In effect, it became virtually an instant success. By 1962, PERT TIME and PERT COST (an off-shoot of PERT TIME) were required on all major defense contracts. However, during the late 1960s, the use of PERT for Department of Defense (DOD) programs seemed to decline almost as suddenly as it had appeared. The rapid acceptance of PERT, the brief period of extensive use, and the swift decline of this management technique is the subject of this article.

Although PERT is understood by many, a short definition is in order. PERT is a networking technique that graphically displays the relationships among the activities and events involved in completing some undertaking. The technique is used typically in project planning and control for the following purposes:

a. Developing project duration estimates by finding a critical path
b. Identifying bottlenecks
c. Allocating resources
d. Monitoring progress
e. Replanning

No distinction is drawn here between specific methods—PERT, Critical Path Method (CPM), and others.

The principle question addressed is "What happened to the use of PERT in weapon system acquisitions"? The study of this question has been focused on Aeronautical Systems Division (ASD) at Wright-Patterson Air Force Base, Ohio. This is the organization within Air Force Systems Command

(AFSC) that manages the acquisition of aircraft and aircraft systems. The investigation included examination of key policies and actions at higher levels within the Department of Defense which are necessarily part of the PERT history at ASD.

The presentation is chronological, presenting first a review of early PERT history and some major programs that used PERT in the early 1960s. This is followed by a discussion of an extension of PERT called PERT COST (a key occurrence in the life of PERT), and the advent of the "criteria" approach in the management of major programs. Finally, there is brief mention of some current applications of PERT and a conclusion setting forth an opinion about what happened to PERT.

EARLY HISTORY

In 1957, the Navy initiated development of a major new weapon system—the Polaris. Admiral Raborn, the weapon system manager, initiated a special study to determine if improved methods of planning and evaluating research and development (R&D) work could be devised for application to the Polaris program. The end result of that study, approximately 1 year after the study began, was PERT, originally named "Program Evaluation Research Task." In several months PERT was in operation for the Polaris program. It encompassed 23 networks and some 3000 activities. The Polaris program was a success (largely because it was a very high priority program, it may be argued) and with that success PERT became a widely discussed and publicized technique.

Early in 1960, Air Research and Development Command, Wright Patterson Air Force Base, (later Air Force Systems Command, Andrews Air Force Base), became the first Air Force agency to adopt a PERT system (then termed Program Evaluation Procedure (PEP)). The Skybolt missile program was the first Air Force weapon system program to use PERT, beginning in the Spring of 1960.

As successive Air Force programs began to impose PERT as a contractual requirement, the need for increased standardization was felt. The AFSC PERT Advisory Board was formed in 1961. The AFSC PERT control board was established in 1962. About this time the government-wide PERT coordinating group was formed.

By 1964, the Air Force had developed and published "USAF PERT," a series of five volumes of detailed guidance in the use of this technique. In 1963 AFSC established the PERT orientation and training center to provide formal, standardized orientation and training to personnel from government and industrial organizations.

In these early years, PERT was widely written about and used by American industry. For example, 1962 research counted 292 articles in periodicals and journals and another 124 in Government publications. A 1964 survey to which 183 companies responded concerning their use of PERT, included applications in the fields of research and development, construction, new products, startups, and other projects. Thus the Department of Defense weapon system acquisition community was not alone in ready acceptance of PERT.

By 1964, PERT was at the peak of its life in weapon system acquisition; major publications had been completed; standardized training was instituted; and PERT was required on all major defense contracts. But before continuing chronologically—it will be useful to note several of the important programs where PERT was used.

PERT AND THE F-4C

In 1960, the McDonnell Aircraft Corporation established an internal PERT capability. Program managers were free to use this service on those aspects of their program to which it was best suited. On the F-4 program, PERT was selectively used for internal planning and control. PERT information was used at three levels of decision—first line management, second line management, and the program manager level. This self-initiated effort was judged to be quite effective, and a significant factor in the F-4C conducting its first flight 65 days ahead of the initial schedule.

PERT AND THE XB-70

The XB-70 was the Air Force's first attempt at a follow-on to the B-52. In 1960 the Air Force directed the prime contractor, North American, to implement PERT for that development program, which was approximately half complete. Although ostensibly PERT was subsequently used by North

American and the System Program Office (SPO), an ASD survey team later concluded that the technique was not used effectively for management purposes and the actual use was limited to routine reporting between the contractor and the SPO. It was further discovered that the SPO had little or no confidence in the reliability and usefulness of the contractor's PERT reports. Thus, one is forced to conclude that this PERT effort, consisting of approximately 6000 activities and PERT reports from six major subcontractors and 20 equipment suppliers and costing the Air Force approximately $10,000 per month, was only marginally useful.

PERT AND THE X-20

The X-20 DYNA SOAR was a research space vehicle to explore piloted, maneuverable re-entry. The implemenation of PERT was directed for this program after the initial planning had been completed. Although the contractor, Boeing, first resisted, a large effort was undertaken by Boeing that resulted in a useful PERT system of 27 networks and 5300 activities. Eventually, it became the sole reporting medium from the contractor to the SPO and was used along with other techniques by Boeing for basic planning, reprograming, and program tracking and analysis.

The X-20 SPO maintained an even larger PERT SYSTEM of 41 networks and more than 10,000 activities and used it to plan and monitor the many interactions between government agencies and contractors. The program office developed and used a status indicator called "recovery ratio"—the ratio of the negative slack (or days behind schedule) to the remaining activity time. Thus various parts of the overall PERT plan could be quickly compared for criticality. Overall, both the SPO and Boeing felt that the PERT effort on the X-20 program was worthwhile.

PERT AND THE C-141

Perhaps the most complete application of PERT occurred on the C-141 program. The prime contractor for this cargo aircraft development program was Lockheed. PERT was used from the contractor's early planning (prior to the Air Force request for proposal) through the first operational C-141 squadron.

Although the contractor used PERT in planning and reporting, the SPO had an active cadre of PERT experts who had the support of the System Program Director. They maintained the only overall network that included all facets of the development program. There was a physical limit to the size of the network, and the operating policy was to PERT only the design and fabrication of parts that were new development, involved new or difficult manufacturing techniques, were very complex, or had traditionally long lead times. The detail of the PERT coverage was dependent upon the risk involved and was expanded on critical items or when unexpected trouble was encountered. This flexibility in the depth of detail resulted in a simple PERT system of considerable usefulness.

The PERT group in the C-141 SPO also instituted a 2-week "management review and action report" which was compiled from the analyzed data of the PERT networks. This approach meant that the network data was properly interpreted by experts and only the overall conclusions or critical items were presented to the SPO management.

The PERT system for the C-141 program had the support of high level management, was used by them, and was highly praised by them. This application was very successful.

SUMMARY OF EARLY PERT EXPERIENCE

What can be concluded about these early uses of PERT TIME? In evaluating these early PERT applications, a 1963 ASD PERT survey team found these benefits:

1. PERT facilitates frequent status reporting,
2. PERT highlights problem areas having possible schedule impact and allows action to be taken to reduce or eliminate the impact.
3. PERT allows integration of activities of all program participants including subcontractors,.
4. PERT is a basis for recovery plans when problems are encountered.

Several cautions identified in this review of early programs were:

1. PERT had not replaced contractor management techniques which had developed over the years, but was a useful complement to them.

2. PERT did not lend itself to active day-by-day monitoring and control of a program. The lag in the updating and the maintenance of networks of several levels of detail precluded such a use.

3. Finally, and fairly obvious perhaps, successful PERT systems need the support of top management and adequate numbers of trained personnel who understand the PERT technique.

So far, we have shown the history through the 1963–1964 time frame of some uses of PERT in ASD weapon system acquisition programs. We have discussed only PERT TIME, and have not mentioned PERT COST— an important element in the eventual decline of PERT.

PERT COST

At the time that PERT systems were being successfully used for the planning, some of the control, and the reporting functions of many Air Force development programs, the need to extend management tools to include program costs was being felt. While the three basic issues for the management of any endeavor are time, cost, and performance, PERT initially was intended only to relate time (or schedule) to performance. Soon after PERT was developed, it was conceived that it could be extended to include the cost parameter.

PERT COST was developed to help meet both the cost and schedule needs of the manager in planning and controlling his program. The heart of PERT COST was the work breakdown structure (WBS) in which a program is divided into small work packages. A work package is normally represented by one or more activities on a PERT network. However, the cost estimates are based on these work packages, not the PERT activities. Work packages were intended to be of about 3-months duration and represent a dollar requirement no greater than $100,000. Control with PERT COST is then based on periodic comparisons between estimated (budgeted) and actual costs for each work package, and also between the estimated and actual time required for each associated portion of the network activity. The fundamental objective of the system should be to identify the planned value of specific jobs and to compare these with actual costs as the jobs are performed. Once again, the basic structure for implementing PERT COST is the work breakdown structure, not the PERT TIME network.

The objectives of this technique were to include both schedule and cost estimates in project planning. Hopefully this would encourage greater visibility of resource utilization in planning. It also was intended as a means to closely track progress for early identification of problem areas such as cost overruns and schedule delays. Even though the concept of PERT COST can be made to sound relatively simple, it is not. It requires properly trained personnel to design the work breakdown structure, implement it, and compute cost estimates. PERT COST therefore was not without some problems.

PERT COST's most fundamental problem, however, was that it was imposed upon contractors, without consideration of an alternative. A basic issue involved the accounting systems of the firms using PERT COST. With PERT COST, costs are measured and controlled primarily on a project basis rather than the functional basis used by most companies. A change of accounting systems is not insignificant to a corporation. Some companies engage in project work organized on a project basis. Many prefer to remain organized on a functional basis. Therefore, the organization and accounting issues were among the first major hurdles many companies encountered when adopting a new PERT COST system. Also the name was misunderstood, and thus the technique was often misapplied. The basis for the "costing" was not the PERT network, but was instead the work breakdown structure, "work packages," that could be related to portions of the network.

THE CRITERIA APPROACH

Because of these problems the concept of PERT COST did not generate the interest that had surrounded PERT TIME. With the "lukewarm" reception of PERT COST by defense contractors, a reassessment of its requirement on every contract was made. The Air Force began to conclude that the forcing of PERT COST on contractors was confusing and wasteful of resources if, indeed, the contractor already had a planning and control system that fulfilled the needs of the government.

Thus, the requirement of PERT and PERT COST began to be replaced with an approach identified as the "criteria approach." This is an approach to scheduling and cost planning and control whereby direction of the specific ouput, and the criteria which a system generating that ouput must meet, are given to the contractor. PERT and PERT COST systems may satisfy the "criteria," but other systems may also.

By late 1967, most references to PERT appeared to be abandoned and the criteria approach had a firm hold in the weapon system management process. This is the approach still in use today. Thus, for whatever the reasons, PERT COST was replaced by the criteria approach and this appeared to influence the fate of PERT in general. PERT COST and PERT TIME had become somewhat synonymous and the very name of PERT fell into much disfavor.

PERT TODAY

Before stating some overall conclusions, it is worthwhile to investigate the use of PERT TIME since 1967. In the late 1960s and early 1970s three large ASD programs, the short range attack missile (SRAM); the new fighter aircraft, the F-15; and the subsonic cruise armed decoy (SCAD), used PERT. In the summer of 1974, of thirteen major program offices of ASD that were surveyed four were using PERT in some form. The four programs were the B-1 strategic bomber, the air launched cruise missile, remotely piloted vehicles, and the instrument flight simulator. The use ranged from complete, detailed PERT networks maintained by the contractors, to small networks developed and maintained by individual program managers to plan and coordinate not only contractor activities, but also government activities. Currently, the program office of the Compressor Research Facility, managed by the Aero-Propulsion Laboratory at Wright-Patterson AFB, uses a version of PERT uniquely developed for that office. These applications of PERT are being made because responsible authorities in these programs feel that PERT induces thorough planning and provides information that otherwise would be difficult to obtain. They feel that, for their programs and their management situations, networking techniques are appropriate. A quick review of current management literature reveals that various network-based planning and control techniques are also being usefully employed in industry.

SO WHAT HAPPENED?

So, what is the answer to the question, "What happened to PERT"? PERT as a technique for overall project planning and scheduling proved itself many times. Unfortunately, when cost became a prime concern and PERT COST was developed, the system was inadequate for a variety of reasons. As stated by General Hans H. Driessnack,USAF, one of the early Air Force users of PERT and later one of the original drafters of the criteria approach, "When PERT COST was developed, it was never intended to put dollar signs on the network." One must conclude that PERT COST was misunderstood by many. Because of problems with the implementation of PERT COST and a general feeling of overspecification in management control systems, the PERT and PERT COST requirements were replaced.

This historical review of a major management technique reinforces several management principles that are well accepted but often difficult to adhere to. First, standardization of approach is good but can be overdone. If overdone, the standard will be applied where inappropriate. Inefficiency will result. Second, never use or require the use of a model or technique until it is well understood. The result can be unpleasant. Finally, there are no panaceas in management. Perhaps the only absolute is to be flexible. What is needed is: understanding of the task and resources; understanding of the techniques available; and continual reevaluation as well as willingness to change.

In a few words, the answer to the question "What happened to PERT"? is that this management technique in its basic form was successful, but because of the inflexibility with which it was applied to all programs, and because it was tied to an unsuccessful extension of itself called PERT COST, the reputation, and thus the ready acceptance of PERT crumbled. Today, selectively applied, PERT is alive and well, having taken its place as a useful management approach for program planning and control.

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INDUSTRY MANAGEMENT OF COMMERCIAL VS DEFENSE SYSTEMS PROGRAMS

by

Mr. Wayne L. Hinthorn

United Technologies Corporation

Are defense hardware programs handled, within industry, differently from comparable civilian programs? In this article, the differences and similarities are interestingly described and evaluated by Mr. Wayne L. Hinthorn of United Technologies Corporation, a member of PMC 75–1, who made a study to: (1) Determine how programs are being managed by industry, (2) Compare the industry application of program management to commercial programs vs defense systems programs, and (3) Identify particularly interesting applications of program management in industry.

PART I

INTRODUCTION

Scope

Although there are a number of articles and books on the techniques of program management, little information on industry management of commercial vs defense systems programs appears in the literature. Most of what has been written is concerned with teaching the specific tools of program management and their application to defense systems programs or military program management. The information presented has been obtained by questionnaire and by interviewing individual program managers or executives within industry.

Because many individuals who provided assistance are members of industrial firms that are in direct competition with each other, companies and individuals are not identified with a specific technique or application unless they have granted specific permission.

The number of industrial concerns that could supply information is almost unlimited. For this reason the scope of this report was limited to a representative sample of firms doing commercial business and firms doing business in the defense systems field. Separate divisions of the same major corporation are treated as individual data samples where their product lines are different or where the divisions operate as independent corporate profit centers. The wide variance in information received from these sources supports this treatment. The information presented here provides an interesting overview of the application of program management within industry, and definite indications of the differences in its application to commercial programs vs defense systems programs.

Twelve companies or separate divisions of the same company were surveyed in the commercial

field. In the defense systems field, data samples were obtained from four representative companies. One of these companies has five separate divisions, and another has four separate divisions. Although the sample size was small, the responses appear to be representative and suitable for the purpose intended.

METHODS AND TECHNIQUES OF PROGRAM MANAGEMENT

Description of Methods and Techniques

Various techniques and management methods were investigated to provide insight to the program management approach used by a given company or division; and to provide some indication of how each organization views the importance of the program function. Some of the techniques evaluated were administrative managerial techniques that could be used by line organization managers as well as by program managers. Other questions asked during interviews and by questionnaire were specifically aimed at determining the value of program management to the organization.

Techniques for planning, work authorization, scheduling, budgeting and cost control were evaluated. Questions focused on:

* *The degree to which formal program plans were used.*
* *The methods of work authorization.*
* *Inclusion of schedule and budget requirements in work authorizations.*
* *The types of schedules used (manual or computer).*
* *Schedule update methods.*
* *Cost control systems used.*
* *Comparisons of planned vs actual work package costs.*

Questions of the following types were asked to determine the importance assigned to program management.

* *Was the program manager identified in proposals?*
* *Were program team members identified in proposals?*
* *Was the program plan prepared by or for the program manager?*
* *What was the extent of program manager schedule control authority?*
* *What was the program manager's authority over design and engineering?*
* *What was the program manager's subcontract management authority?*
* *Who had control of production cost?*
* *Who had authority for quality and reliability?*
* *What was the program manager's management reporting level?*
* *What was the program manager's need for higher management approval of his decisions?*
* *What was the number of people assigned to the program?*
* *What was the size of program in dollars?*
* *Did members of the program office have specific management training?*

Questions were also asked to determine the approaches to management which were found to be particularly effective by the individual program managers.

PART II

METHODS USED TO MANAGE COMMERCIAL AND DEFENSE SYSTEMS PROGRAMS

Study of the management-administrative techniques employed by various companies and programs revealed a wide variety of practices in use. (Ref 1). The similarities and differences in these management approaches may have useful meaning in comparisons of commercial vs defense systems programs. The results of the study for each major technique are outlined below.

MANAGEMENT ADMINISTRATIVE TECHNIQUES

One of the management or administrative methods studied was the use of a formal program plan to describe in detail the scope of the program and the work required. Of the twenty-four separate programs surveyed, a program plan was used in all but three cases. Three programs where a plan was not used were commercial programs where (1) the standard product line was small, (2) the program was small and (3) the company was familiar with the product, thus making such a plan unnecessary.

Formal work authorizations were used by all companies, both commercial and defense oriented, except in two cases where the particular administrative procedures used did not require such authorization. In these cases, one commercial and one defense, sales orders took the place of the authorizations. Table 1 applies.

In a majority of programs, the formal work authorization contains some budget and schedule information (end dates in the case of schedules and total program budget, at a minimum.)

As shown in Table 2, schedule techniques vary considerably between companies and between commercial and defense systems programs. Somewhat surprisingly, PERT, CPM or critical path networking appear to be more widely used for commercial programs than for defense systems programs. This may be indicative only of the fact that two large engineer construction firms were among the companies surveyed. In the case of these two companies, the complexity of their major construction programs in the power plant, mining and many other fields makes the use of techniques such as CPM or PERT networking mandatory. However, three other organizations engaged in commercial work also use PERT or CPM, whereas only three companies of those surveyed in the defense systems field used PERT, CPM or other network techniques.

Table 1. Plans and Authorizations

Type program	Formal program project plan		Formal program work authorizations		Work authorization content			
					Budget information		Schedule information	
	Yes	No	Yes	No	Yes	No	Yes	No
Commercial	9	3	10	2	7	5	6	6
Defense	9	3	12	0	10	2	12	0

Table 2. Scheduling Techniques Used

	Commercial Programs	Defense Programs
Network	6	3
Milestone	1	3
Gantt	7	12
LOB	1	2

All twelve defense systems programs used manual scheduling techniques primarily. Only five commercial programs relied primarily on manual methods. Three other commercial programs used computers exclusively, and four used both manual and computer techniques.

It is probable that the size of the programs in the defense systems field, which were generally small to medium size (5 to 85 million dollars), influenced the fact that networking techniques were not used more often. The attitude of many of the companies in the defense systems field is reflected by the statement of one program manager that PERT is generally considered a discredited technique. One company with a program in the 350 million dollar range uses milestone and Gantt charts. This is in comparison with the engineer construction firms where computerized critical path network scheduling is used for every program, and is apparently extremely useful to both the company and the client.

Schedule updating frequency and method were found to vary on the basis of the type of program (very dynamic, routine, or in between) and the particular needs of the program. See Table 3.

Table 3. Schedule Updating

	Commercial	Defense
Daily	1	0
Weekly	1	3
Biweekly	1	2
Monthly	2	3
Nonperiodic (as required)	7	4

Cost control is an important requirement for both commercial and defense systems programs. Therefore, the type of cost control employed by the various companies and programs was of major interest. Nine of the twelve defense system oriented programs were using the DOD Cost/Schedule Control System Criteria (C/SCSC) approach to cost control. One additional program implemented a modified earned value type of system. This program probably would have implemented C/SCSC if not for the small size of the division and the implementation costs. See Table 4.

Of perhaps greater significance is the fact that, of twelve commercial programs, one firm was using the C/SCSC system and three others used an earned value system not too different from the C/SCSC system.

Table 4. Cost Control, Methods and Techniques

Type program	Cost control methods			Are work packages used for cost control?		Are actual vs planned costs compared?	
	Earned value	Cost/schedule control systems criteria	Computed vs actual	Yes	No	Yes	No
Commercial	7	1	4	7	5	12	0
Defense	2	9	1	11	1	12	0

Regardless of the techniques in use, the responses from program managers revealed that perhaps the dominant concern of all program managers was the control of costs.

All of the defense systems programs were using the work package technique of breaking the work into small tasks. Half of the commercial programs were also applying this technique in one form or another. As might be expected, because of the critical concern for controlling costs, all of the programs were attempting to compare planned vs actual cost. The concern for cost control and particular techniques employed are discussed more fully later.

Program Manager Authority and Status

The major emphasis of this study was to see if there were interesting differences between the management of commercial programs as compared with defense systems programs. Many of the questions asked by interview or questionnaire were aimed at determining the value the organization places on the program manager as related to the success of the company. Table 5 outlines the responses.

The first question considered in this category was whether the program manager's name was placed in proposals for new work. This practice was found to be commonly used for both commercial and defense systems programs except where the product in the commercial field is a more or less standard product line and the identification of the program manager would have little meaning to the customer who is buying a known commodity.

The inclusion of the names of program team members in proposals for new work was found to occur with greater frequency in companies engaged in defense systems programs. This difference in emphasis may be because in commercial programs the client wants assurance that a program manager who is known to have successfully satisfied client requirements under past contracts, or has been recommended by other clients, will be assigned to the program. The commercial client already knows that the company is qualified in the field, and therefore has little interest in the program team members. By comparison, the customer for defense systems programs, (usually the government), is very much interested in the team the contractor proposes to assign to the program. Knowledge of the team is a means of determining whether that team has the skills and experience to complete the program successfully.

The extent of participation of the program manager in the negotiation process with the proposed customer was also examined. It was apparent from the responses obtained that all of the companies with commercial *and* defense systems programs attach a rather high value to the participation of the program manager in the negotiation process. His participation usually takes two forms: one is as a background coordinator or policy maker; and the other is as a direct participant in the negotiations. In one case of a firm with a defense systems program, the chief negotiator was actually the program manager designee.

The use of a program plan was previously discussed under administrative techniques. As would be expected, this plan was found to be the program manager's document, whether or not he actually signs the document, and it is used to establish the program goals and to define the specific tasks to be performed.

Since costs are of primary importance to the success of a program, the program manager's authority over initial budgets for both manhours and subcontract dollars was studied. The results indicate that the program managers of defense systems programs almost always have complete budget authority for their programs. However, it is not unusual for the program manager, in firms engaged in certain types of commercial programs, not to have control of one or more elements of the program budget. This was true, for example, in one company in the nuclear reactor field where engineering design costs for a more or less standard reactor product line are prorated to the various customers for that reactor and the engineering design budget is the responsibility of the engineering organization manager. Again, this difference between commercial and defense systems programs appears to be more the result of the special needs of a particular commercial product line than a significant difference between program management of commercial vs defense systems programs.

Table 5. Program Manager Authority

	Is name of PM in proposals?	Are PM team names in proposals?	Is PM member of negotiation team?	Does PM approve program plan?	Does PM control labor budgets?	Does PM control subcontract budgets?	Does PM control program schedules?	Does PM have authority or significant influence over engineering design?	Does PM approve or disapprove engineering design?	Does PM control product build cost?	Does PM monitor build cost closely?	Does PM have technical authority over subcontracts?	Does PM have approval authority over subcontracts?	Does PM have authority over quality control?	Is approval of PM actions by higher management required	For major changes only?	For major and minor changes?
Commercial Programs (affirmative answers)	6	3	8	9	9	11	12	9	8	11	11	8	6	3		12	0
Defense Systems Programs (affirmative answers)	11	10	12	12	12	12	11	12	11	11	11	11	8	3		11	1

The extent of the authority of the program manager over engineering design, subcontracts, and the quality and reliability of the product, is discussed later in the analysis and evaluation of program manager techniques and methods. In these areas of responsibility the program manager's authority and influence differs widely from program to program and from company to company.

Another factor studied was the extent of program manager authority and degree of concern with the control of the "build cost" of the product. Build cost, simply defined, means "how much does the product cost to produce"? This implies that build cost must be controlled from the start of the design process to prevent development of a product that will be excessively costly to produce. The term also includes all of the other cost factors such as the cost of purchased parts and efficiency of the production process. The responses from program managers indicated that they were extremely concerned with the "build cost" and that they monitored this factor very closely. One program manager engaged in a commercial aerospace program defined a cradle to grave approach to monitoring "build cost" which is reviewed in the next part of this report.

Little difference was found between commercial programs and defense systems programs at the organizational level to which the program manager reports. The level varies from company to company ranging from the company president or division president down through the executive vice president, vice president, major department manager or manager of programs. Regardless of the title of the individual to whom the program manager reports, the level was seldom lower than the third layer from the top in the organizational hierarchy and in many companies it was higher. This would appear to indicate that in companies that have adopted the program management organization as generally understood, the program manager is considered to be an arm of the general manager (term used as descriptive of the top management level) for the program to which he is assigned. (Ref 2, p 7). See Table 6.

Table 6. Management Reporting Level

Commercial	Management Level: Program Manager reports to	Defense
1	President	1
4	Vice President	6
5	General Manager	5
2	Department Head	0

The number of people reporting to the program manager differs widely because of the organizational approaches of the different companies and divisions and the different types of programs. It is in this area that some of the key differences and similarities between commercial and defense systems program management were indicated. Most notably, there is no necessary correlation between the size of a program in dollars and the size of the permanent staff. See Table 7.

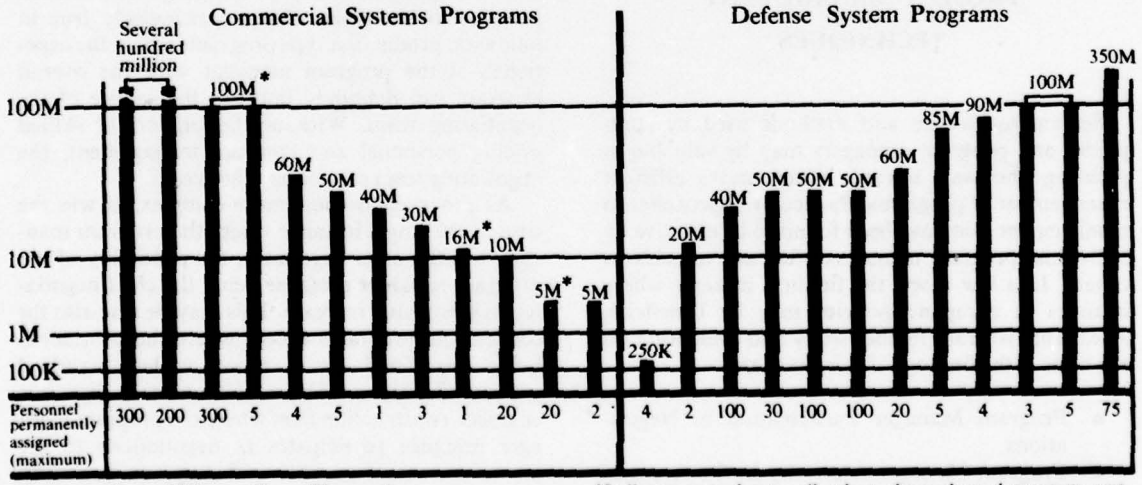
Job skills of personnel in the program organization follow what is probably a normal pattern ranging from engineers and other technical personnel through production, financial, budget, and schedular personnel.

The dollar value of the programs managed by the program managers surveyed varied from as low as $250,000 to hundreds of millions of dollars. Despite this wide variation, it was interesting to note that the spirit, enthusiasm, and determination which the various program managers displayed in their answers to questions regarding their programs differed little whether the program was of a large or small dollar value.

The question of specific program management training was explored because it might provide some indication of the significance of program management. This is true for the military program manager.

The Department of Defense, through the Defense Systems Management College at Fort Belvoir, Virginia, provides an extensive 20 week Program Management Course for military personnel, military department civilians, and some industry personnel. Although all of the companies represented in the sample provide various types of management training or make available such training outside the company, only three companies provided specific training in *program* management.

Table 7. Program Costs Compared with Personnel Assigned



Notes: M = Million K = Thousand

*Indicates annual rate, all others show planned program costs

One of these companies is a large, technology-oriented organization with diverse programs and products in both the commercial and defense systems field. It provides specific program management training in a 2-week course conducted in conjunction with a major university. Whether or not this example and the example offered by the Defense Systems Management College point the way to future upgrading of the skills of program managers is unknown; however, this writer expects that the advantages of offering specific training in program management will become obvious within industry as industry comes more and more in contact with program managers who have received such training.

Although many other areas having significance to the management of programs could have been evaluated, the subjects reviewed above provided sufficient basis to form at least some preliminary conclusions as to the differences between industry management of commercial programs and defense systems programs. These differences and the significant approaches and applications of program management which were discovered are evaluated in Part 3.

PART III

EVALUATION OF PROJECT MANAGEMENT TECHNIQUES

Several techniques and methods used by companies and program managers may be valuable in pointing the way toward better, more efficient management of programs. Particular approaches to management that have been found to be effective by individual program managers often are valuable to others. In a few cases, the findings indicate where changes in company policies may be beneficial. Areas that warrant further study and evaluation on the basis of the findings of this study are:

- Program Manager Participation in Negotiations
- Program Manager Authority in the Areas of Engineering Design
  Subcontract Management
  Quality Control and Reliability
- Product Cost Control
- Requirements for Management Approval
- Project Organizations
- Individual Program Manager Techniques

PARTICIPATION IN NEGOTIATIONS

The extent of the program manager's participation in the negotiation process for new business was of interest because it may indicate the importance of the program manager to the program and to the company. From the data obtained, there appears to be no significant difference between the extent of participation of program managers of commercial programs and managers of defense systems programs. In both cases, the degree of participation varied from that of a monitor, coordinator, or background strategist, to that of a direct participant in the negotiations in a supporting role, or as the negotiator. In a single instance, the program manager of a defense systems program was the chief negotiator, and it was he who received the support of marketing, pricing, and contract management.

From personal experience, the direct participation of the program manager at the negotiation table can be a significant factor in bringing a coordinated position to the table. This is particularly true in follow-on production type programs where the experience of the program manager with the overall program can definitely improve the calibre of the negotiating team. Without the support of skilled pricing personnel and contract management, the negotiating team cannot be effective.

As programs become more complex, as was the case in the single instance where the program manager was the chief negotiator, the possibility of the program manager designee being the chief negotiator will probably increase. This may be true also for commercial programs except where the contract is being negotiated for a more or less standard production item. This is indicated by one engineer construction firm where the program manager designee participates in negotiations to the maximum extent possible and may, on occasion, be the negotiator.

AUTHORITY FOR ENGINEERING DESIGN

Traditionally, in defense systems programs, it is common to assume that one of the key elements of program manager authority is that of control of the engineering design through definition of the requirements and design approval. The results of this study show that although this authority for engineering design still remains with the program manager of defense systems programs, the situation is quite different for commercial programs. In six of the twelve commercial programs, the program manager does not have design approval authority and has little influence over the engineering design except from the standpoint of cost. This is illustrated by one of the engineer construction firms that has developed an organizational structure that appears to be extremely effective. In this organization, the functional disciplines such as engineering have complete responsibility for maintaining the highest possible calibre of work in their particular discipline. Even though the entire project team is collocated under the overall direction of the program manager, responsibility for the engineering design remains with the functional engineering manager.

AUTHORITY FOR SUBCONTRACT MANAGEMENT

Closely allied with the program manager's authority in the area of engineering design is his authority for subcontract management as reflected by whether he has technical authority in the subcontract area and whether he approves subcontracts and changes. Here too, the traditional view of program management is that authority for subcontract management is one of the major responsibilities of the program manager. (Ref 3, p 53).

As in the case of authority in the engineering design area, of those surveyed, fewer program managers of commercial projects had technical authority in the subcontract area than did defense systems program managers. As for approval of subcontracts, the results were almost identical for both commercial and defense systems programs with only fifty percent of the program managers having such approval authority. The question that may be asked is, without such authority, how can the program manager be held responsible for cost control? In the case of the engineer construction firm previously mentioned the organizational discipline and the program manager's influence, in the subcontract area where the cost is a consideration, may be sufficient. In another instance the program manager of a firm, high in the defense systems aerospace field, stated frankly that the relationship of the program with the purchasing or procurement function was "strained." Other companies seem to have at least partially resolved this potential problem by having assigned a procurement representative as part of the program team even though this representative continued to report to the head of the functional procurement organization. Findings for another company, also in the aerospace field, indicated that the degree of authority remaining in the functional area is sufficiently great to result in the possibility of actions by the procurement organization which could be detrimental to the best interests of the program. This tends to be supported by the following finding of the Aerospace Industries Association, as cited in the Harvard Business Review:

> "....one survey of aerospace companies revealed that the inclusion of the procurement function in a program organization results in improved performance sufficient to offset the usual higher operating cost...." (Ref 4).

Further study may be indicated to determine ways of improving the subcontract management function in the program organization.

AUTHORITY IN THE QUALITY ASSURANCE AREA

Another area of program manager responsibility where there appears to be no clear definition nor understanding of the program manager's authority is the area of quality control and reliability. While some of the responses such as that from one company in the nuclear field are clear (responsibility for

quality control in the nuclear field is carefully controlled by legal requirements), in many instances, the only authority of the program manager in the quality and reliability area is in terms of influence and the overall program requirements. A major reason for this in defense systems programs is probably the requirement for independence of the quality control function as expressed in military specifications such as MIL-Q-9858A. (Ref 5).

Some projects appear to have accommodated the need for program manager authority by assigning a quality control representative to the project team. The results of this study nevertheless indicate that this is potentially one of the major areas of weakness in program manager authority. Obviously if the quality of products is deficient or excessive quality control costs are incurred, these factors can have a detrimental effect on the success of the program and on the effectiveness of the program manager.

BUILD COST

One of the more interesting findings of this study was the approach to controlling the "build cost" of a design as applied to one complex program in an extremely competitive commercial field. The program, involving major development work, was started by performing thorough, parametric cost estimates of all competing products. Then a determination was made as to what the cost of the proposed product had to be to be competitive. When this was completed, a detailed cost estimate was prepared by the responsible functional organizations in the company. The parametric cost estimate was then compared with the detailed cost estimate and where differences were found actions were taken to determine what the cost should be. Next, a fixed ceiling cost, not a target cost, was assigned to every part. In this way the program cost goal is maintained and absolute determination to meet these ceiling costs is required from every member of the program team. When a design that appears to exceed the cost ceiling is completed, the design, procurement, or manufacturing approach is reviewed to define the action necessary to bring the part cost within its ceiling.

This concept is closely allied to the current DOD concept of "design to cost." However, the program manager of this program expressed two perhaps significant reservations in regard to "design to cost." First, he expressed the opinion that "design to cost" will not be effective when the cost goal is imposed by an outside source. This occurs when a "design to cost" figure is imposed on a contractor. It was the program manager's opinion that for "design to cost" to work, the cost figure must be arrived at by the hardware developer. Secondly, this program manager stated that for "design to cost" to be effective, the cost figure assigned to each part must be a *ceiling* rather than a *target* cost.

MANAGEMENT APPROVAL REQUIREMENTS

The requirement for upper management approval of the program manager's actions was found to be generally the same for both commercial and defense systems programs. There did appear to be a slight difference of emphasis in the application of approval requirements. Program managers are usually required to obtain higher management approval of their actions by exception only. The exceptions cited were usually when the basic framework of the program plan or contract must be breached, such as for major changes in scope, schedule, or breaches of allowable budget authority. These requirements for upper management approval are outside the normal framework of weekly or monthly management reviews.

The findings for commercial programs indicated that the program managers were given slightly more latitude in directing the programs than were the managers of defense systems programs. This was found to be particularly true for one large, multiproduct organization where the program manager, who is called a venture manager, is given almost complete latitude to run his program within the limits of the business plan for the program and management reviews. This is particularly interesting since the type of programs in which the company is engaged may be several years long and involve very large expenditures.

PROGRAM ORGANIZATIONS

The organizational structure of the programs studied varied from the pure program or aggregate organization to the individual or staff program organization. (Ref 4, p 21). All four commonly seen types of program organizational approaches, i.e., individual, staff, intermix, and aggregate types, were represented. In addition, there were combinations of the above types of organizational approaches that appear to have been developed because of the particular needs of the project or because of company management philosophies or constraints. When an organizational structure other than the pure program organization was used the matrix principle, where specialized support is drawn from the functional organization, was generally used. Some significiant variations in application of the matrix principle were noted. Interestingly, the use of the pure program or aggregate program organization for the programs surveyed was restricted to programs in the commercial field. All defense systems programs that were surveyed could be generally characterized as using the matrix principle, although in one case the organization appeared to be moving toward an aggregate type.

The first interesting application of program management, from an organizational standpoint, is represented by the approach used in the engineer construction companies. An outstanding example of the use of the pure program organization is that of one of these firms that has developed and applied the matrix principle to the pure program organization. In this company the entire program organization is located in the same area. The personnel in the organization are individually selected for the program team from persons suggested by the functional organization managers. However, *if* the manager of the functional engineering or procurement organization, for example, suggests the assignment of individuals to the program who are unacceptable to the program manager, the program manager may veto the assignment. He may also request, although not always successfully, the assignment of particular individuals whom he believes to be best qualified for the program. Individuals assigned in this manner still report administratively to their functional organization manager and receive their performance reviews from the functional manager. This is similar to the collocated approach which is common to some military program organizations. (Ref 6, p 35).

In the particular engineer construction firm where this approach is used, two significant factors tend to counteract two major objections to pure program organizations. One objection is the supposed reduction in technical proficiency thought to occur when a specialized individual is located away from similar specialists in his functional organization. This objection is countered by making the functional manager of engineering, for example, responsible for assuring that the technical performance of the individuals assigned to the program meets all of the standards of that specialty as defined by the company.

The second often stated objection to pure program organization, that of diffused responsibility for individual personnel performance reviews, seems to be effectively countered by this firm. This is accomplished by leaving the responsibility for performance reviews with the manager of the functional specialty, but requiring that the program manager, who may be more familiar with the details of the individual's performance while he is assigned to the program, prepare an advisory performance review for the use of the functional manager.

The responsibilities of the functional organization managers in relation to those of the program manager appear to be very clearly defined in this engineer construction firm. For example, the program managers understand that they are not responsible for the technical aspects of the design, nor for procurement, except as these matters affect the program cost and schedule. In these organizations, the program manager is responsible for the "what" and "when" part of the program with the "how" being left to the specialists in the functional areas.

This appears to work exceptionally well for this firm, which has a sales backlog of 2.5 to 3 billion dollars. The functional managers apparently understand that they must give the programs the best possible support. At the same time, the responsibilities of the program manager for meeting the requirements of the client and for making a profit for the company are well defined and clearly understood within the company.

Client or customer satisfaction receives great emphasis in the engineer construction field. Second only to the program manager's responsibility for

completing the program successfully, which means at a profit, is his responsibility to satisfy the client so that the firm can expect additional business from the customer. In a field involving major design and construction programs such as refineries, ore processing facilities or power plants, the life blood of the company is the next program the satisfied client will place with the firm.

Lastly, in the case of the engineer construction organizations discussed here, the philosophy of collocating the program team is followed whether the program team consists of three or three hundred people.

Where a matrix type program organization was used for both commercial and defense systems programs, the majority of the program organizations could be characterized as being staff program organizations with the number of personnel directly reporting to the program manager numbering from one to five. In most cases, however, this small number of direct reporting personnel is deceptive since many more personnel from the functional organization are directly assigned to the program and report to the program manager, although continuing to report administratively to the functional organization. This type of combined matrix type program organizational approach and pure program approach seems to have surmounted the common problem of the matrix organization, in which the allegiance of the personnel in the functional organization sometimes remains more with the functional organization than with the specific program.

In at least one instance, although the functional organization assigned a program representative to the program, the predominant allegiance of that individual appears to have been to the functional organization more than to the program, making this approach relatively ineffective. Significantly, in the instance noted, the number of people reporting directly to the program organization was large compared to the usual average, perhaps indicating the need to bring functions directly under the program manager for more effective control.

Where the program managers surveyed indicated a strong preference for the matrix type program organization, it was apparent that the individuals who were directly assigned to the program from the functional organizations understood their obligation to the program clearly, and were not affected by the split allegiance.

A third example of an organizational approach to program management which is somewhat unusual when compared with the customary defense industry approach is that used by a large, research oriented, multiproduct company operating solely in the commercial field. In this firm, the program manager, who is called a venture manager, is given a great deal of freedom within the confines of the business plan that establishes the program. The program manager is allowed to structure his organization in the way he considers suited to the program. This means that some ventures may operate with a very small program team while others may construct an organization that may closely resemble an intermix or aggregate type program organization. While the venture manager is encouraged to use the staff organizations, such as engineering, to perform the program work as in the usual matrix approach, he is free to incorporate the necessary skills within his own organization if he desires. A stated advantage to this approach is that it tends to keep the staff organizations responsive to the needs of the venture managers who usually come from the industrial departments (each responsible for a major product line) of the company. The success of this approach is indicated by the fact that the staff departments of the company have essentially no budgets of their own. Because a venture manager may choose to subcontract work, as opposed to having it performed by the staff department, the health of the staff departments in the company is probably indicative of the fact that they do a superior job of providing required services.

A further aspect of this company's approach is that the venture manager always has at least three key members on his team. These three members reflect the overall company approach based on the tripod of research, manufacturing, and marketing. The venture manager will begin the program with the support of a key man from the research or technical side, a similar individual from the production or manufacturing side, and another individual from the marketing side of the particular industrial department responsible for the program. This is similar to the matrix organizational approach used by the majority of the programs which were investigated, but the early inclusion of a production representative and a marketing representative is not typical of the program organizations for most defense systems programs.

INDIVIDUAL PROGRAM MANAGER TECHNIQUES

The question of individual program manager techniques was investigated. The fundamental question was, "What approaches work successfully for you as an individual program manager"? A summary of the data obtained is given in Table 8.

Table 8. Major Factors Contributing to Program Manager Success

Factor	Times mentioned
Technical competence and knowledge of the program	5
Communication and listening ability	14
Concentration on important details	2
Individual initative, qualified people, aggressiveness	15
Timely decisions and early recognition of problems, visibility	6
Team cooperation, trust, morale	11
Minimum paperwork	3

Most of the factors emphasized in program manager responses are well-known management principles such as effective communication, team work, qualified and dedicated personnel, and technical skill. Some of the points mentioned deserve further examination. Several comments received from companies with commercial programs may be significant.

One of the major engineer construction firms emphasized competence of the program manager in his application of sound management principles, attention to important details, and early recognition of potential problems. Also, mentioned was the requirement for program manager knowledge of the resources available and the effective application of those resources.

Two firms with commercial programs stated that the most important ability of a program manager was that of satisfying the client.

An unusual organizational environment was indicated by a program manager in one company where a low key, low pressure approach to the job is apparently of major importance. In this organization, the program managers are making an effective contribution by getting people to work together. The absence of formal controls, a concept not usually associated with defense systems program management, was mentioned as a key contributor to success. A program manager in a different division of the same firm stated that his most important function is to bridge the gap between the line managers. This comment may be significant because the firm is using program management to increase the sales of a product line which was severely affected by recent business recession.

A company with many commercial product lines stated that program management success was a function of a small team approach, low overhead, strong dependence on individual initiative, and a minimum of checks and audits. This company believes that overcontrol is likely to result in lost time and profits.

Another company with extensive commercial product lines also described some unusual factors contributing to venture manager success. The venture manager in this company is given a new program with few rules to govern his actions, and a requirement for minimum paperwork. The venture managers are usually bright, young, aggressive individuals who haven't yet learned that "it can't be done." The keynote of the organization appears to be effective communications, with everyone including the first line supervisor having a clear understanding of his part in the program. Communications in this organization easily flow upward, downward, and horizontally. A participative management approach is used, and some programs have actually been successfully managed by a three man

committee. The venture managers are given full responsibility and held accountable for the success of the programs.

One of the commercial program managers indicated that the most important factor contributing to success is mutual trust between the functional organization and the program manager. The same program manager mentioned the importance of program spirit and the selection of the right individuals in the functional organization to be program representatives. Other program managers in other divisions of the same company expressed the opinion that prompt attention to problems, program visibility, communicative ability, and the built-in checks and balances of the matrix organization are the keys to success.

Another program manager in the same company stated his belief that not getting lost in the details is an important factor. He believes that a program manager should not try to get perfect answers to every question, but should be satisfied with ninety-five percent correct answers. Time spent in trying to reach the perfect answer may actually be detrimental.

One program manager stated that people who are capable, hardnosed, opinionated, self-starters are the most important requirement. He selects team members who are smarter than he is, and he will not tolerate "yes" men.

Another program manager who emphasized the need for the program manager to be a good listener also mentioned mutual trust within the organization, technical competence of the program manager, motivation, and dedication.

Several managers stated that the presence of skilled people in the functional organizations is the most important requirement for success.

In another defense systems program, the program manager felt that welding the team through good communication was the key. He practices this to the extent that he holds periodic meetings with the secretaries to improve their understanding of the program goals.

Other program managers felt that appropriate delegation of authority, constant attention to the program, and management by objectives are most important.

Insistence on excellence of performance, personal initiative, minimum interference with the functional organization, avoidance of confrontation, and the ability to recognize when a decision must be made were also stated as being essential to program manager success.

Although none of the responses received were extreme or unusual, they reflect some refreshing approaches. The attitude of managers of commercial programs for the most part seems to indicate the presence of a more relaxed, generally less bureaucratic, and possibly more innovative approach than is usually the case in the management of defense systems programs. Whether this is a factor that should be considered by companies and program managers having defense systems programs is discussed in the conclusions and recommendations of this report.

PART IV

CONCLUSIONS AND RECOMMENDATIONS

What conclusions can be reached from this report? Are there lessons that may point the way to more effective program management within industry? Does the application of program management to commercial programs indicate ways to improve the management of defense systems programs?

Although sometimes subtle, differences between the management of commercial programs and the management of defense systems programs are evident. These differences may have application for commercial systems managers, for defense systems managers, and for military program managers.

FINDINGS APPLICABLE TO INDUSTRY

Most of the conclusions of this study suggest approaches that may have application in the

management of defense systems programs within industry. All of the findings need further consideration, yet, the conclusions suggested may point the way toward advances in the management of programs.

The major conclusions follow:

An apparent disparity between commercial programs and defense systems programs in the use of networking techniques such as PERT and CPM is indicated.

The size of the defense systems programs surveyed may have unintentionally influenced the results obtained, and it is possible that networking is used for the very large defense systems programs in industry. However, the responses obtained from the defense systems program managers indicate that they see little value in such techniques. This attitude may be strongly influenced by the unsatisfactory experiences of individuals with the application of PERT in the mid 1960's. If so, it is possible that the defense systems program manager in industry should re-evaluate the use of networking, scaled to the size of the program, as a technique that could provide greater program control.

While sweeping conclusions cannot be drawn from the findings of this study, it would appear that the role and function of the program manager in the contract negotiation process may need further evaluation in many companies. In summary, the question should be asked: "Should the program manager be the negotiator, or should he continue to play a background supporting role"?.

The results obtained indicate a wide disparity in the amount of authority held by individual program managers for engineering design, subcontract management, and quality control. It is not possible to state the single correct approach that should be used for every program. Obviously, the proper approach is the one which is most effective for the particular program.

The results may indicate that program management could be improved by greater program manager authority in the procurement and subcontract area. Perhaps the best way to obtain this improvement would be the assignment of a procurement representative to the program team.

Similarly, a change in the amount of program management authority in the area of quality control in defense systems programs might lead to greater success. Again, a firm conclusion is not offered, but the results do show that the program manager's influence is usually least in this area.

The absence of formal program manager training in industry was one of the clear findings. The potential for such training is indicated by the emphasis it is receiving within the Department of Defense and by the three companies surveyed that are providing such training.

The success of such training will be determined in time. Meanwhile, the possibilities and advantages of such training should be investigated by the industrial community.

The findings appear to indicate that improvements in the morale and dedication of the functional organizations in relation to the projects and programs are still needed in many companies having defense systems contracts.

How can the functional organizations be made to be more productive members of the program team? Do the functional organizations realize that their success is irrevocably linked with the success of the programs?

Here, the approach used by the engineer construction companies could be applied to obtain more responsiveness in the functional organizations.

The matrix organization, with assigned program team members in the functional organizations, has partially solved the problem. However, this is still a troublesome area in many companies. Only through an improved understanding of the importance of the program and continued improvement in organizational approach can there be greater program management success.

The emphasis which many of the commercial organizations place on the program manager's function of satisfying the customer indicates an area of possible improvement in the management of defense systems programs.

Although the defense system program manager in industry is many times beset with the problems of technical requirements and cost control, he can never afford to ignore the need to satisfy the requirements of the customer. Perhaps many defense systems program managers should devote more attention to this important aspect of program management.

Customer satisfaction may be enhanced by increased training for both the industry program manager and the military program manager.

FINDINGS APPLICABLE TO THE MILITARY

Possible implications for the military program manager and the Department of Defense follow.

The concept of design to cost, which is receiving much emphasis within the Department of Defense, will probably be improved as more experience is gained. In applying this concept, a single finding of this study indicates that the Department of Defense should attempt to find out how industry applies this concept. If products cost too much to produce, they cannot be sold at a profit. Therefore, industry has always had to apply the principle of design to cost. These applications may hold the key to the success of the concept in weapons system development.

A possible solution to the often-repeated problem of the military program manager in obtaining the effective support of functional organizations within the military departments is suggested.

It may be possible for the military departments to apply two of the approaches used by one of the major engineer construction firms surveyed. These organizational methods are:

- Functional organization responsibility for the technical adequacy of the work performed by people assigned to the program, and
- elimination of the often-expressed fear that personnel located with the program organization may somehow lose their technical proficiency when located away from those with similar skills.

In practice, if the heads of the functional organizations are clearly aware of their responsibility to insure the technical adequacy of the work performed by their people who are assigned to the program manager, perhaps their support of programs will be more effective.

FINDINGS APPLICABLE TO INDUSTRY AND THE MILITARY

Perhaps most significant of all, is the conclusion that the commercial program manager generally functions in an atmosphere of greater freedom than his counterparts in the defense systems and military program fields.

This was indicated by the results that showed the commercial program manager is generally subject to fewer rules, regulations, and administrative paperwork than is the defense program manager. The working environment of the commercial program manager evidently is more conducive to innovation and technical advance.

In contrast, the industry defense program manager usually works in an environment of closely controlled company policies, and the specifications, requirements, and restrictions of the contract. Regardless of how necessary these requirements may be, they do restrict the latitude of the program manager's freedom to develop innovative solutions to problems. Further these requirements absorb a great deal of time that might be more profitably spent on subjects critical to the success of the program.

Similarly, the military program manager works in the midst of a myriad of governmental rules, regulations, reporting requirements, and audits of his actions. Again, as necessary as all of these bureaucratic requirements may be, they must, of necessity, stifle innovation and retard progress.

A solution to the problem is not given here. The greater freedom of commercial program managers suggests that ways can be found to prevent the growing bureaucracy surrounding the weapons systems development field from counterbalancing the productivity of the military and defense systems program manager.

Mr. Wayne L. Hinthorn is a graduate of DSMC Program Management Course 75–2. Mr. Hinthorn is the Manager of Development and Production, United Technology Corp., Chemical Systems Division, Sunnyvale, California. He is a 1951 graduate of the University of Colorado and has held numerous management assignments associated with the development, test and production of technical systems. This article is based on an Individual Study Paper that earned designation as a *Commandant's Distinguished Study*.

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The purpose of ~~the Defense Systems Management~~ this Review is to disseminate information regarding new developments and effective actions taken relative to the management of defense systems programs and defense systems acquisition. (→ cont on P iv)

The Review is designed as a vehicle to transmit, between persons in positions of leadership and responsibility in the program management and systems acquisition communities, information on policies, trends,

Item 20 Continued.

events, and current thinking affecting the practice of program management and defense systems acquisition. The publication serves as a means for providing an historical record of significant information associated with defense systems acquisition/management concepts and practices.

The Review supports the assigned mission of the Defense Systems Management College, and serves as a medium for continuing the education and professional development of persons in the field of defense systems acquisition/management.

Item 7 Continued.

Mr. Carroll Eugene Garrison
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